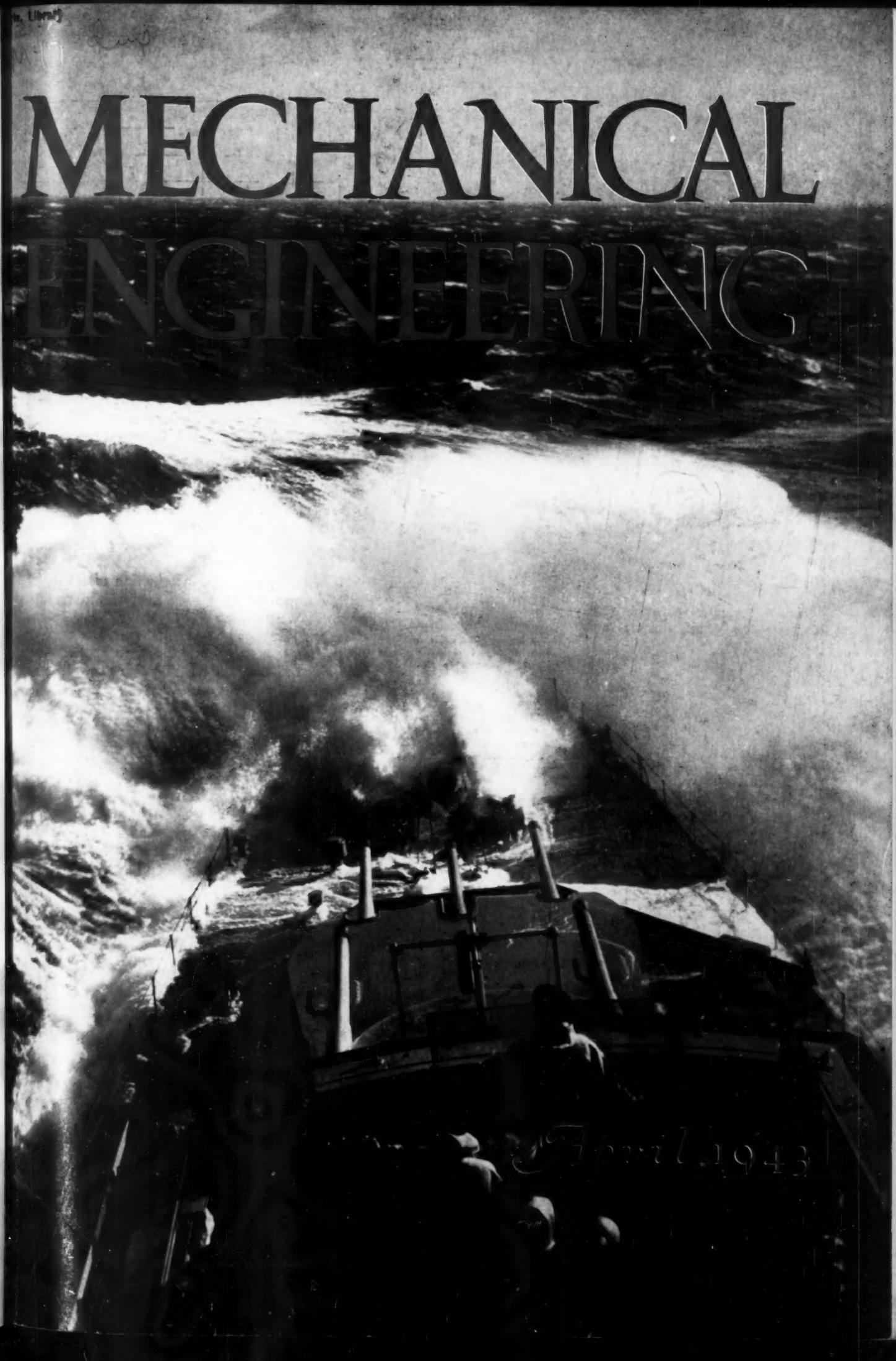
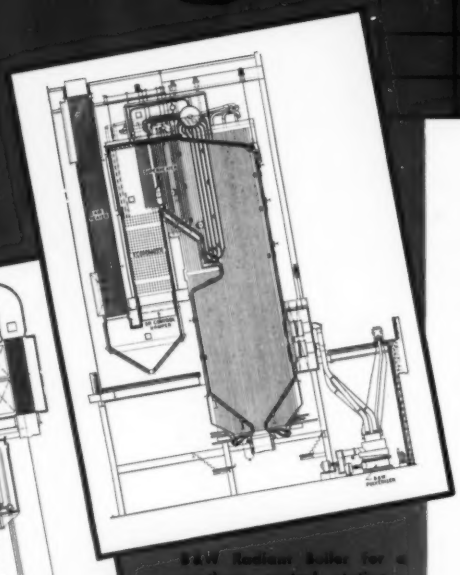
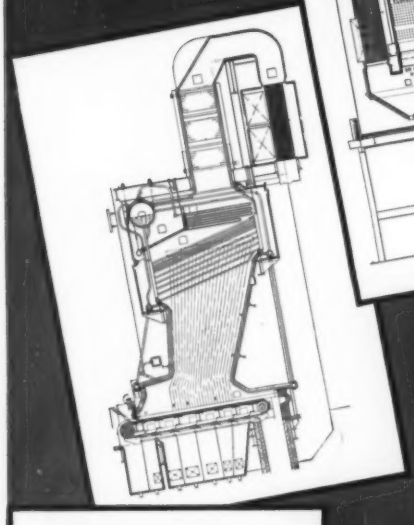
MECHANICAL ENGINEERING



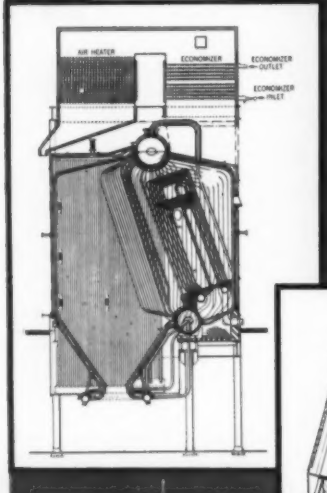
Helping Make Statistics



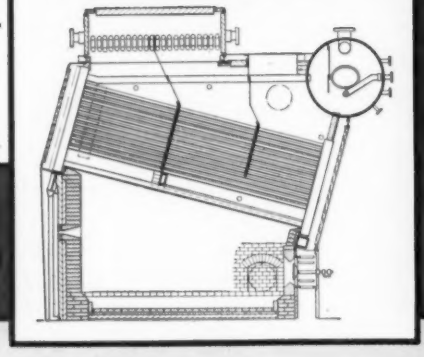
B&W Radiant Boiler for a southern central station—Cap. 400,000 lb. steam per hr.



B&W Cross-Drum Boiler in a mid-western central station—Cap. 180,000 lb. steam per hr.



B&W Integral-Furnace Boiler for an eastern central station—Cap. 150,000 lb. steam per hr.



Sectional side elevation of the Liberty ship boiler.

Statistical peaks in war-time power production have been made possible in no small degree by boilers built by B&W. The Open-Pass, Radiant, High-Head, and Integral-Furnace Boilers, the more recent of B&W's designs, have definitely established their ability to supply large blocks of power reliably. Standard B&W Cross-Drum and Stirling boilers need only passing mention as statistics makers—they have made records in their fields for many decades.

Noteworthy as is the production of steam for industrial power by B&W boilers, the records made in the marine field by other B&W boilers are equally impressive—whether in naval or other government service, or in the merchant marine. Statistics of ships placed in service might well be interpreted in terms of additional B&W boilers gone to sea, since B&W builds the greatest proportion of marine boilers. And one of B&W's designs was chosen by the Maritime Commission for all of its Liberty Ships, and all manufacturers of Liberty Ship boilers are working to B&W drawings.

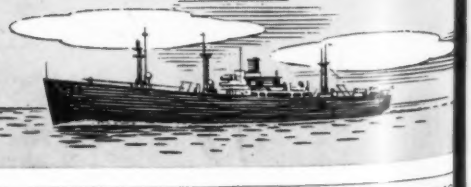
So, whenever statistics on steam-power production appear, in the background are B&W boilers helping make the statistics possible. And, after the war, when materials for boilers for general service are again freely obtainable, B&W boilers with inherent richer experience will be available.

The Maritime "Navy" E and an "M" pennant flown proudly alongside the Navy "E" at the Barberton Works. Each is an award for "outstanding achievement" and is "an honor not lightly bestowed".

C-34

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO., 85 LIBERTY ST., NEW YORK, N. Y.



MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 65 NUMBER 4

Contents for April, 1943

THE COVER	*United Nations Cruiser Heads Into Rough Seas*	
ORDNANCE DEPARTMENT TRAINING	*B. B. Abrams*	233
HYDRAULIC-TURBINE PRACTICE OF THE T.V.A.	*H. J. Petersen and J. F. Roberts*	237
ADVANCES IN PLASTICS DURING 1942	*G. M. Kline*	245
ADVANCES IN RUBBER DURING 1942	*J. H. Dillon*	248
THE AMERICAN ENGINEER AND THE WAR EFFORT	*A. A. Potter*	251
RECENT DEVELOPMENTS IN CARBIDES VS. HIGH-SPEED STEEL	*H. A. Oldenkamp and James McFadyen*	253
CUTTING METALS FROM THE USER'S POINT OF VIEW	*L. B. Dorsner*	257
ONE METHOD OF MEETING CUTTING-TOOL MATERIAL PROBLEMS	*H. H. Tobey*	259
GAS-TURBINE LOCOMOTIVE WITH ELECTRICAL TRANSMISSION	*P. R. Sidler*	261
CONSERVING THE USE OF CRITICAL MATERIALS	*B. D. Kunkle*	267
GLASS FOR PRECISION GAGES	*H. B. Hambleton*	274
RECENT PUBLICATIONS ON STATISTICAL METHODS	*H. A. Freeman*	277

EDITORIAL	231	REVIEWS OF BOOKS	289
COMMENTS ON PAPERS	278	A.S.M.E. NEWS	292
A.S.M.E. BOILER CODE	288	CONTENTS OF A.S.M.E. TRANSACTIONS	308

INDEX TO ADVERTISERS 94

OFFICERS OF THE SOCIETY:

HAROLD V. COES, *President*

W. D. ENNIS, *Treasurer* C. E. DAVIES, *Secretary*

PUBLICATIONS STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

COMMITTEE ON PUBLICATIONS:

C. R. SODERBERG, *Chairman*

F. L. BRADLEY, *Vice-Chairman* L. N. ROWLEY, JR.

E. J. KATES R. F. GAGG

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

N. C. EBAUGH, GAINESVILLE, FLA. O. B. SCHIER, 2ND, NEW YORK, N. Y.

Junior Member: J. A. CONNON, NEW YORK, N. Y.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1943, by The American Society of Mechanical Engineers. Member of the Audit Bureau of Circulations. Reprints from this publication may be made on condition that full credit be given MECHANICAL ENGINEERING and the author, and that date of publication be stated.

U. S. Navy Official Photo

Officer at Periscope in Control Room of Submarine

VOLUME 65
No. 4

MECHANICAL ENGINEERING

APRIL
1943

GEORGE A. STETSON, *Editor*

Chas. T. Main

NOT many weeks ago Chas. T. Main, Inc., architect-engineers, of Boston, announced that they had been in business 50 years. On March 6, at Winchester, Mass., Chas. T. Main, past-president, A.S.M.E., A.S.M.E. Medalist in 1935, and chairman of the Board of Chas. T. Main, Inc., died at the age of 87, thus ending a long and distinguished career.

Mr. Main's active engineering career began with his graduation from the Massachusetts Institute of Technology in 1876. That year marked the Centennial Exposition at Philadelphia which initiated one of the most extraordinary periods of industrial development the nation has yet seen. Power, machinery, and manufacturing industries, manned in many cases by graduates of the engineering colleges, were beginning to satisfy the material needs of a vast continent whose frontiers were pushing further westward. There was abundant opportunity for men willing and eager to work in a rapidly expanding reunited nation that was beginning to feel the growing pains of an industrial economy. It was men like Chas. T. Main who brought the full genius of their engineering talents to bear upon the industrial problems confronting the nation.

Mr. Main lived to see the faltering of that industrial economy which spread so much havoc in the postwar years of the 1930's. He lived to see the cataclysmic aftermath of world-wide depression, the start of a global war. He personally and through his firm wrestled with the problems of every phase of prosperity, depression, war, reconstruction, and the present war. In expansion of industry, in the contraction resulting from idle factories and idle men, in the rehabilitation of France after World War I, and in the construction of Camp Edwards for World War II he adapted his knowledge and experience to the pressing needs of the moment. His name will always be associated with the textile industry, with the development of steam, water, and hydroelectric power, with mill design, and the valuation of engineering and industrial properties.

Calm, gentle, dignified, his kindly smile and courteous manner won for him the affection and respect of younger men. He enriched his profession by means of his writings. He served engineering societies by sharing with them his engineering knowledge and his administrative wisdom. He was a friend of engineering education, as a teacher in his early years and as a life member of the corporation of the Massachusetts Institute of Technology. He found time for public and municipal affairs in posts where his engineering knowledge and cultural interests were at the service of his fellow citizens. His life was long, useful, and distinguished, and it was filled with good works.

War Dress

WITH this issue MECHANICAL ENGINEERING goes into war dress in the interests of paper conservation. Margins have been trimmed by an amount that saves approximately 12 per cent over the former size. Other economies will probably have to be made as restrictions on the use of paper become more severe, as they have already in England. These are already under consideration. Curiously enough, margin trimming has not reduced the number of words on the printed page but has increased it, because three lines per column, six per page, have been added in order to restore the proper balance of type-space and page-size proportions.

Readers of MECHANICAL ENGINEERING will remember that the A.S.M.E. anticipated paper conservation a year before the War Production Board's Limitation Order L-244 made it mandatory. Appealing to the engineer's inherent desire to eliminate waste, President Parker addressed a letter to all A.S.M.E. members last spring asking permission to remove from the mailing lists of Transactions and the *Journal of Applied Mechanics* the names of all who, for one reason or another, did not make use of those publications. The response was more than generous. As a result of Mr. Parker's letter the annual rate of paper saving effected has amounted to nearly 20 per cent of the paper used to print the Transactions and *Journal of Applied Mechanics* in 1942. Naturally, this was not the actual saving made last year, as the program was not in effect for the full year and many new members have been added to the mailing lists. However, the saving is none the less real. Its effect will be felt during the present year and greatly ease the paper problem. Members of the Society have a right to know this and will be gratified that the saving was made voluntarily.

Go to Meetings

THE Council of The American Society of Mechanical Engineers recently received from The Institution of Mechanical Engineers an exquisitely bound photostatic copy of the original rules of the Institution, published in 1847.

Legend has it that The Institution of Mechanical Engineers was formed because its first president, George Stevenson, the locomotive builder, was refused membership in the Institution of Civil Engineers on the grounds that he was a mechanic rather than a civil engineer. However that may be, the statement is made in the rules that "this Institution is formed to enable Mechanics and Engineers, engaged in the different manufactories, railways, and other establishments, to meet . . ." although

the qualifications of membership required that "members shall be persons who are, at the time of their election, managing heads of establishments in which engines or machines are made . . . ." The Institution from the start thus established high qualifications for membership.

Most interesting of all, however, is the rule about the duties of members. For example: "Every member shall lay at least one communication before the society tending to advance professional knowledge or shall pay £1. fine towards the library funds, in case of his non-compliance." The prestige of Institution membership carried obligations to contribute to the fund of human knowledge and was not merely an opportunity to learn from others. This is a sound principle, recently emphasized by President Coes of the A.S.M.E. in his message to A.S.M.E. members, MECHANICAL ENGINEERING for March, "I get out of the Society just what I put into it (aside from money) in furthering its objectives, in building up the profession, and in service to the public."

Needless to say, the Institution today has no rule fining its members, now numbering more than 15,000, for not laying "at least one communication before the society." With engineering-society memberships and publication expenses what they are today, more "communications" are received than can be published. But there is still plenty of room at meetings of engineering societies and in most cases plenty of opportunity for members to take part in oral discussions, thus adding to the value of the papers presented.

Today, in spite of the fact that mechanical engineers are busier than ever before owing to war production, attendance at A.S.M.E. meetings has been growing. The reasons are not far to seek. A glance at any program, for example, that of the 1943 A.S.M.E. Spring Meeting, to be held at Davenport, Iowa, April 26–28, announced in the News Section of this issue, will show that practically every session is devoted to subjects directly related to war production. Moreover, conditions make it difficult and sometimes impossible for authors to prepare papers in time for preprinting. Many cannot be published. But the experience of listening to the presentation of up-to-the-minute engineering papers and the discussion of them and of making a personal contribution to that discussion is extremely invigorating.

Davenport is centrally located with respect to a vast area in which war industries are in full swing. A few days' respite from the routine of exacting tasks will renew vigor to accomplish those tasks. Those responsible for our war-industries program recognize the value of engineering meetings in wartime and encourage attendance by taking part in those meetings themselves. Opportunity to attend such meetings becomes a duty as well as a privilege.

Glass Gages

ONE of the fruits of substitution of materials, at present in the early stages of development, is the precision gage of glass about which Col. H. B. Hambleton writes in this issue. At the meeting in New York at which Colonel Hambleton presented the paper referred to, a large audience of engineers engaged in a long and informative discussion of the subject he brought to their attention for the first time. Aided by engineers of two of the glass companies who manufacture the glass blanks that gage makers grind into precision measuring devices and by other officers of the Ordnance Department, he answered frankly dozens of questions and promised that the paper he is to present at the Spring Meeting of the A.S.M.E. at Davenport will contain much new material that is being developed in this rapidly advancing subject.

Anyone who listened to the presentation of the paper and the discussion will be convinced that only by going to Davenport to hear the second round of the reports can he benefit fully from the information that is coming to light with such startling rapidity. No production engineer who prides himself on keeping abreast of present developments can afford to miss the Davenport meeting. He will not only hear an up-to-the minute discussion of glass gages but will have an opportunity to learn about recent developments in other phases of war production.

Hydraulic Turbines

FOR more than a decade the activities of the government in developing hydroelectric plants has afforded engineers abundant opportunity to advance the art of designing and constructing dams, hydraulic turbines, construction methods and equipment, and a host of auxiliary devices. Probably at no period since the development of power at Niagara Falls half a century ago have these arts been so rapidly advanced.

During this period the knowledge of design and construction methods in the field of hydraulic turbines has increased enormously. The Tennessee Valley system alone comprises 20 plants with 70 units, as an article on hydraulic-turbine practice of the T.V.A., published in this issue, points out. As in all engineering developments of the character of those of the Tennessee Valley Authority, responsibility and credit must be divided among many persons and organizations. No such projects can be the result of the genius of a single man or of a single group. From those in charge of the fundamental plans and designs down through the ranks of hundreds of organizations to the men at drafting board and machine, talents and skills have been forthcoming in abundance. The result is more than the hydroelectric plants themselves with all that they mean to the communities they serve. It includes also the recorded knowledge gained by means of the work done on the projects. This knowledge becomes the heritage of the present and future generations.

A small item in the A.S.M.E. News Section this month announces the availability in handbook form of a large portion of the experience one manufacturer of hydraulic turbines has gained during recent years. One can imagine that this material, brought together by Arnold Pfau, will be avidly sought by other engineers interested in the principles of design of hydraulic turbines and practical problems of speed and pressure regulation.

ORDNANCE MEN DELIVERING BOMB TO AIRPLANE

ORDNANCE DEPARTMENT TRAINING

Representatives of Engineering Colleges Visit Aberdeen Proving Ground

By CAPT. B. B. ABRAMS, U. S. ARMY

ORDNANCE DEPARTMENT, WASHINGTON, D. C.

TWENTY-THREE presidents and deans of engineering colleges representing 22 states recently had the opportunity to observe training methods of the Ordnance Department. The tour of inspection of the Aberdeen Proving Ground, Maryland, was arranged by Brigadier General Julian S. Hatcher, Chief of the Ordnance Military Training Division, in co-operation with the Association of Land Grant Colleges.

At the Ordnance Replacement Training Center and the Ordnance School, in the short period of three days, the visiting educators practically lived the life of the average ordnance soldier from the day he enters the service until he is graduated—a minimum of six months later—as a newly commissioned Second Lieutenant of Ordnance. Owing to time limitations, the average graduate seldom gets instruction in more than one specialty, but the visitors were privileged to see at firsthand all the classes and specialties required to supply and maintain ordnance in the field.

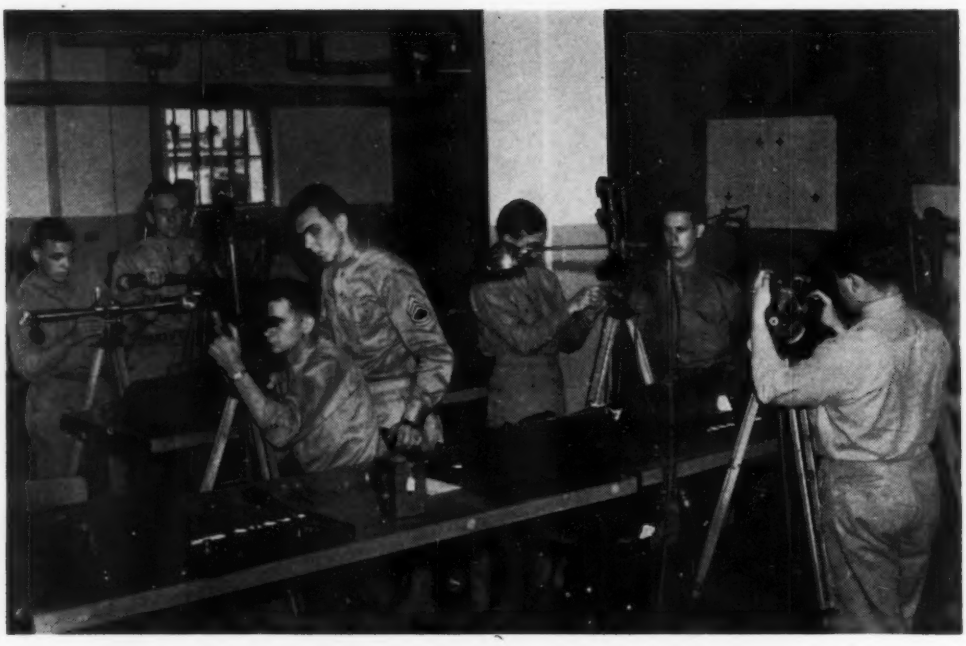
FUNCTION OF THE ORDNANCE DEPARTMENT

The Ordnance Department is a service at the beck and call of all branches of the military service. In addition to serving the Army, it is also at the disposal of the Navy, Marine Corps, and the Coast Guard. When one of these arms desires a gun or a tank, the Ordnance Department makes pilot and test models. If the model meets tests of the branch originally ordering the weapon, orders are placed with the Ordnance Department. The matériel is then manufactured in government arsenals or, if impracticable, by civilian industry under the supervision of the Ordnance Department. It is then issued to the using branch, but in so far as the Army is concerned, ordnance's function does not cease there.

Just as our larger industries follow up their production with preventive and general maintenance, so does the Ordnance Department follow up its numerous products with maintenance in the field. Where the test of the average automobile is in our cities and on usually well-constructed roads, the test of ordnance lies on the battlefield, ranging at present from the frozen tundra of Russia to the equatorial heat of Africa.

MAINTENANCE BECOMING MOST IMPORTANT FACTOR

A general definition of ordnance is that: "If it's shot, shoots, or rolls, it's ordnance," and included in this long list are the delicate sighting instruments used by artillery and the directors which insure accurate antiaircraft-fire control.



INSTRUMENT REPAIRMEN ADJUSTING BATTERY COMMANDERS' TELESCOPES AND FIRE-CONTROL EQUIPMENT

This unquestionably is a tremendous job and one to which the mechanical engineer invariably is unusually well fitted. The first phase of the present war may be considered over—that is, production. As announced recently by the Chief of Ordnance, with the exception of one item, fire-control instruments, our armament program, which includes that of our allies, is running ahead of schedule and beyond the fondest expectations. The fire-control instrument problem, we have been assured, will be on a satisfactory basis within a very short time.

It is well known that once American industry has been tooled up for mass production of any item, comparatively little work remains with the exception of keeping the program running smoothly. This is being done.

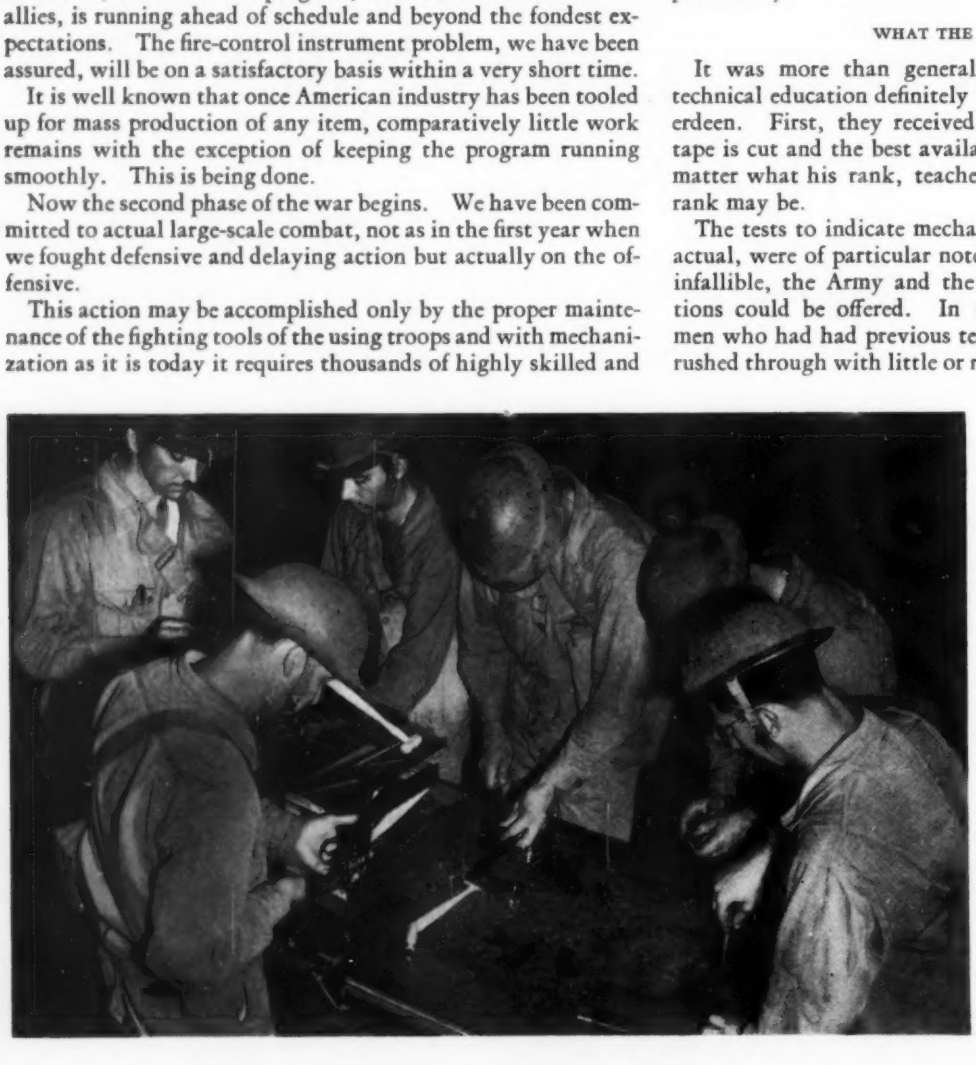
Now the second phase of the war begins. We have been committed to actual large-scale combat, not as in the first year when we fought defensive and delaying action but actually on the offensive.

This action may be accomplished only by the proper maintenance of the fighting tools of the using troops and with mechanization as it is today it requires thousands of highly skilled and trained officers and enlisted specialists. This is the problem. Ordnance has done well in streamlining its courses in turning out these officers and men on a mass-production basis. The technical schools must now do their part in changing old-fashioned stereotyped methods to fit in with the needs of the present day.

WHAT THE VISITORS SAW

It was more than generally agreed that these leaders in technical education definitely benefited from their visit to Aberdeen. First, they received a firsthand picture of how red tape is cut and the best available man in a particular field, no matter what his rank, teaches others, no matter what their rank may be.

The tests to indicate mechanical aptitude, both written and actual, were of particular note. Naturally, these tests are not infallible, the Army and the visitors agreed, but no suggestions could be offered. In the basic shops, they observed men who had had previous technical or mechanical experience rushed through with little or no delay. Others, with no actual



SMALL-ARMS CLASS—PISTOLS, RIFLES, AND MACHINE GUNS

MAINTENANCE INSTRUCTION ON ONE OF THE LIGHT TANKS

experience, whose written tests showed promise, were struggling with their mechanical tests—a block of cast iron 2 in. × 2 in. × 4 in. on which, with hand tools only, 23 separate operations were performed. Still others were being taught the proper way to handle such everyday tools as hammers and screwdrivers.

The Army probably suffers just as much as any other group from priorities, and it was enlightening to see a makeshift 35-cent rubber dart pistol being used to adjust artillery in direct-firing instruments costing $2500. The extensive use of large-scale visual aids designed and made by the staff and faculty of the ordnance installations at Aberdeen aroused unusual comment, and it was pointed out that there is still no priority on the use of discarded packing boxes, sheets of cellophane, and a bit of paint. In every classroom and shop continued nods of approval could be observed—in the shop where new men were filing their cast-iron blocks, through classes in small arms, artillery, automotive equipment, and tanks, and finally in the handling of antiaircraft fire-control instruments. Following right along with the specialists were their assistants and co-workers; machinists, carpenters, painters, electricians, welders, blacksmiths, and the other numerous trades needed to properly perform the field-service function of the Ordnance Department.

COLONEL CONWAY DESCRIBES TRAINING DIVISION

Practically no time was given to talks; the session was opened with a short address of welcome by the commanding general, Aberdeen Proving Ground, Major General Charles T. Harris, Jr. The group was then taken in charge by Col. Harold J. Conway, deputy chief, Ordnance Military Training Division. Colonel Conway gave a complete picture of the organization and mission of the Ordnance Department, laying particular stress on the Military Training Division. In making the problem clear in the shortest space of time, Colonel Conway said: "The M4 tank, which has proved its worth many times over on the battlefield, was designed by the Ordnance Department. It met the specifications of the requesting arm and was put into production by the Ordnance Department. Ordnance supplied the tank and it is now on the battlefield. The Armored Force furnishes five men to operate and fight with this tank, but stand-

A CLASS IN GAS WELDING

ing behind these five men are thirteen different trades under competent officers to maintain this weapon. Not thirteen men but trades, fully equipped with mobile shops, tools, and material to keep them fighting. In the Air Force, without ordnance service, the plane may well remain on the ground as target for enemy artillery and aircraft, but with its guns supplied and serviced by ordnance, its ammunition and bombs brought up to the plane, it is an unequaled weapon of the war." In his summation he said: "General Eisenhower, in Africa, is not interested directly in what is coming off the production line in Detroit but he is definitely interested in every weapon under his direct control being in perfect condition. A single tank serviced and returned to the line may at times be worth a thousand at our factories or ports of embarkation. Two armies come together in combat. Sooner or later both armies must retire with holding forces protecting the line. Men and machines have definite limitations of endurance but should our ordnance soldiers do their job just thirty minutes sooner than the enemy can do his job, he is at our mercy."

REPLACEMENT TRAINING CENTER

The visitors spent the first day in the Replacement Training Center where the new men are given their training as soldiers for four weeks. Instruction and field problems in offense and defense against all types of warfare are given. All of us have seen in the newspapers and heard over the radio the efforts made to destroy lines of communication. The word "communications" is taken too literally. Actually, lines of communication in the main consist of a continuous stream of supplies and also maintenance. Ordnance officers and soldiers are continually under fire. Recently, a list of Purple Heart awards for wounds received in action against the enemy was published. Listing 86 awards to American soldiers, it is of note that 15 went to men of the Ordnance Department, one posthumously.

THE ORDNANCE SCHOOL

The second day was spent in the Ordnance School. Here selected men from the Replacement Center are given specialized training in their particular field. Men from the field forces who have shown outstanding ability are returned for further and additional specialization. As a matter of fact, the Ordnance School may well be considered the postgraduate school for ordnance officers and enlisted men. Many courses are held for officers in the field and here the success of the graduates and undergraduates of the engineering schools is most outstanding.

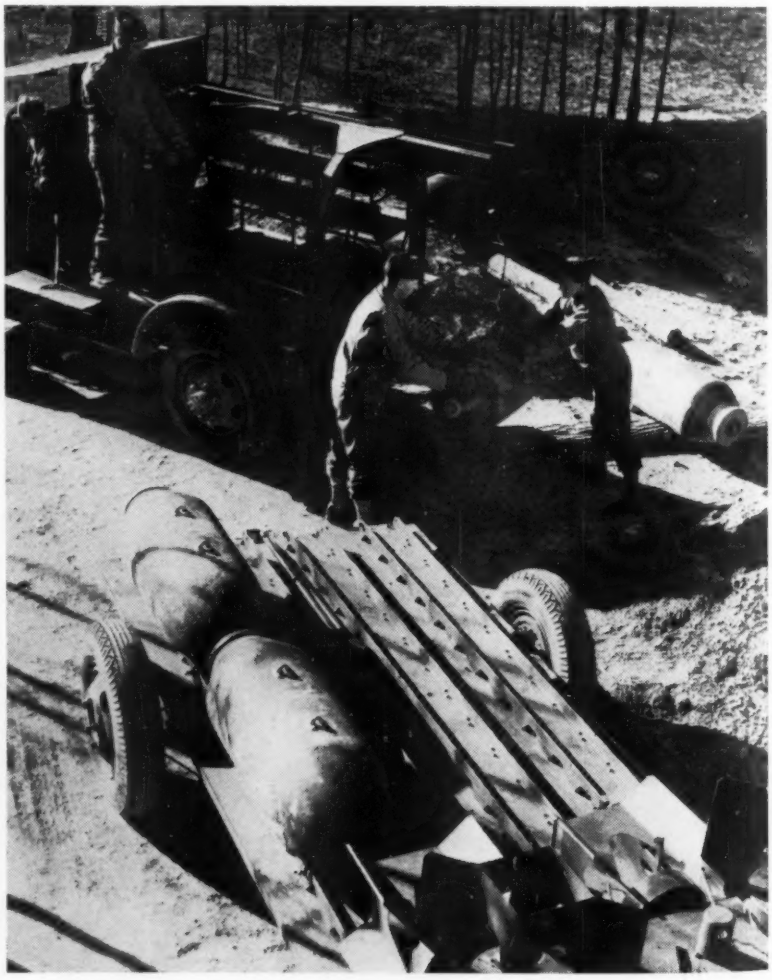
ORDNANCE OFFICER CANDIDATE SCHOOL

The third day was taken up inspecting the Ordnance Officer Candidate School. In this school, men with their basic military and technical training completed may, upon application and approval by a board of officers, enter and graduate three months later as officers. Officer candidates have far from an easy time of it. Gold bars do not come easily. For thirteen weeks they work from 8:45 in the morning until 9:30 at night. With the exception of an occasional few hours over the weekend, they are always under the watchful eye of their officers. For two months of this time, all of these potential officers pursue the same course of instruction, to include Army administration and the general knowledge every officer must have. In the last month, when specialization in one of the technical fields is begun, the engineer shows the benefit of his former training. He may be far from any work he has previously done or thought of doing but his background brings him to good stead.

It will probably be much easier for the future Officer Candidate now that so many of the technical educators have seen at firsthand what their students may expect when they enter the Army.

Of necessity, great stress must be placed upon leadership and it may well be worth the while of our civilian schools to give this subject much thought. Officers must be leaders. It can't be taught in the now crowded schedule after the man is once in the Army but this trait should be developed while the man is still in the college or university. Consideration of this particular factor will prove of great help to both the man and the Army. In the critique held just before the session closed, many questions were asked and answered but that making the deepest impression was the explanation that the Ordnance Department or any other branch of the Army cannot select its students the way the colleges can and do. They take what is assigned; with the men assigned they do the job. The Army does not countenance alibis. We are told that here are a given number of men and in a given period we expect these men to take their places in the field as trained maintenance soldiers. It must be done. We cannot say we do not have equipment or facilities. If we don't have them we improvise them and the forced improvisation stands the men in good stead later.

There are no air-conditioned shops in the desert nor heat in Russia, but the job is done.



ORDNANCE SOLDIERS GETTING READY TO FIRE AND FUSE BOMB

HYDRAULIC-TURBINE PRACTICE *of the* T.V.A.

By H. J. PETERSEN[1] and J. F. ROBERTS[2]

PROJECTS currently under construction will increase the installed hydroelectric capacity of the Tennessee Valley Authority system to 1,560,000 kw, with provision for an ultimate installation of 2,030,000 kw. Steam-power stations provide an aggregate capacity of 340,000 kw for supplementary service during periods of water deficiency and to compensate for reduction of power at hydroplants due to loss of head during extreme floods.

This hydraulic-power system, with its approximately 70 units in 20 plants and with all the variations of head, load, capacity, etc., for the different projects, affords an interesting variety of typical plant arrangements. With two exceptions (which have Francis turbines), the main-river developments employ propeller turbines, usually of the Kaplan type, to meet varying conditions of head and load. Storage developments on the five principal tributaries are provided with moderate-head Francis-turbine installations, while the so-called secondary-storage developments, on streams having relatively limited storage but steep slopes, are the tunnel and surge-tank type, equipped with medium-head Francis machines. Figs. 8 and 9 show a section through a high-head Francis-type and a low-head Kaplan-type powerhouse, respectively.

The eight original units at Wilson, which were placed in operation in 1924 and 1925, formed the nucleus of the Tennessee Valley Authority power system. Five more plants were acquired by purchase from the Tennessee Electric Power Company in 1939. The assistance of the Bureau of Reclamation was obtained for the selection and purchase of four additional units. All the rest of the turbines were purchased by the engineering staff of the Authority.

FACTORS AFFECTING SELECTION AND DESIGN

The economics of power-plant design is controlled by the specific speed, peripheral coefficient, and critical sigma, i.e., the cavitation limit of the turbine selected. These factors are all interrelated and, in a properly selected turbine, they are compatible. A higher specific speed results in lower-cost turbines, generators, and powerhouse, yet this higher speed must not be obtained at the expense of a safe plant sigma value, nor at the expense of energy lost in the draft tube because of the excessive discharge velocity. A margin of safety of a few feet over the limiting value of the static draft head should always be observed in order to keep the plant sigma above the critical sigma.

Furthermore, the turbine should be selected on the basis of its performance under the known operating conditions of the plant, i.e., variation in head and tailwater elevations, plant usage factor, and the relation between the power output at the particular plant to the power requirements of the whole integrated system.

These basic rules were generally observed in selecting the turbines for the Authority. However, on some of the Francis turbines with heads 90 ft and above, the specific speed was reduced to what might be considered relatively low and conservative. In several such cases where these plants operate over extreme ranges of head, a specific speed was selected which would be mechanically safe for the runner when operating under the extreme heads. Such a unit operates at a relatively low specific speed when considering the rated head which may be as low as 70 per cent of the maximum head.

In the main-river plants which operate under low heads and varying tailwater elevations, it was necessary, in order to obtain a high enough plant sigma for all conditions of low tailwater, to set the runner below normal tailwater, thus obtaining a negative static draft head. This, of course, results in the wheel's being flooded normally and, in order to gain access to the runner, an unwatering system using pumps was installed. A draft-tube water-depressing system was installed in these plants to lower tailwater below the runners to enable the wheels to revolve in air when operating as synchronous condensers. The design of these water-depressing systems will be discussed in more detail.

Fig. 1 shows the specific speed of the various units plotted against rated head. The range of values for these units runs from 36 to 360 ft head and from a specific speed of 32 to a specific speed of 163. Inasmuch as the values plotted on this curve are taken from turbines having different draft heads, they will

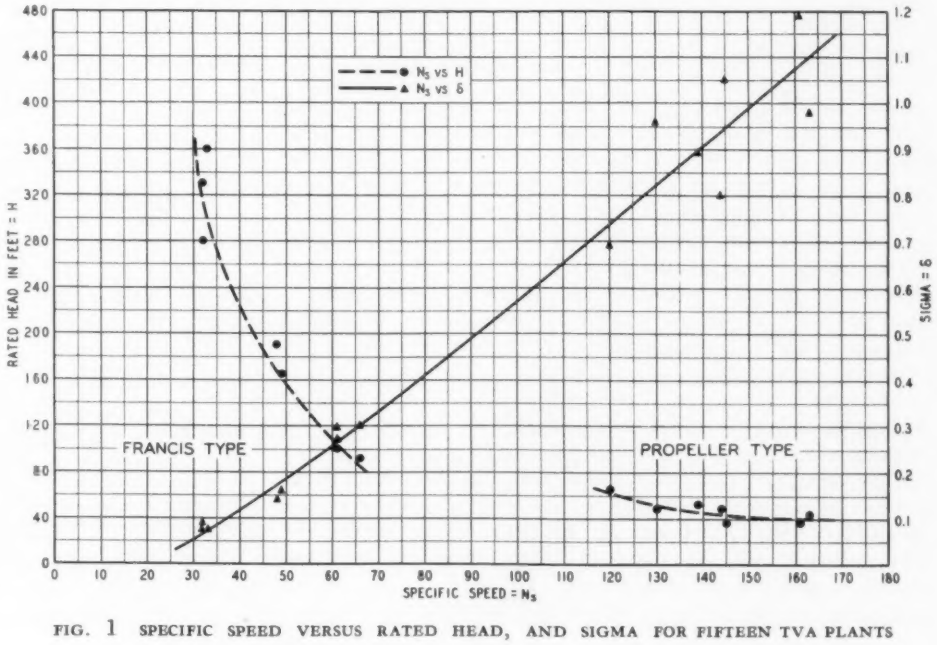


FIG. 1 SPECIFIC SPEED VERSUS RATED HEAD, AND SIGMA FOR FIFTEEN TVA PLANTS

[1] Head Mechanical Design Engineer, Tennessee Valley Authority, Knoxville, Tenn.

[2] Manager, Hydraulic Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; formerly Head Hydraulic Engineer, Tennessee Valley Authority, Knoxville, Tenn. Mem. A.S.M.E.

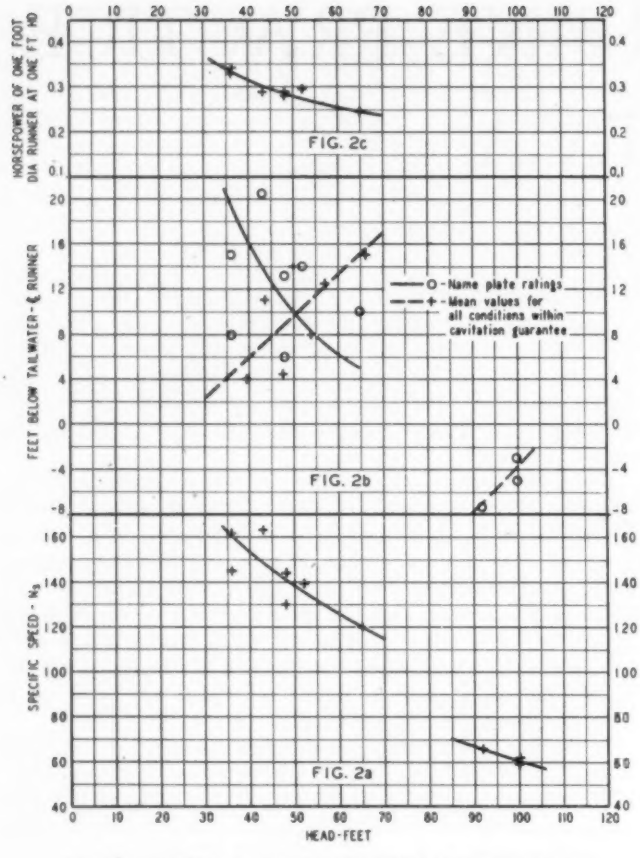

HORSEPOWER OF ONE FOOT DIA RUNNER AT ONE FT HD
FIG. 2c
FEET BELOW TAILWATER - ℄ RUNNER
O - Name plate ratings
+ - Mean values for all conditions within cavitation guarantee
FIG. 2b
SPECIFIC SPEED - Ns
FIG. 2a
HEAD-FEET

FIG. 2 RUNNER DATA FOR TVA HYDRAULIC TURBINES

not form a true curve. Hence, this curve is only intended to show the trend and should not be used as a criterion or basis of design for other plants. The seemingly conservative specific speed for some of the Francis turbines has already been commented upon.

In Fig. 1 is also plotted the sigma values of the plants, sigma being plotted against specific speed. The sigma values lie close together for the Francis turbines but are widely scattered for the Kaplan and fixed-propeller-type turbines. This can be expected when it is understood that the Kaplan turbines operate over extreme head variations, and the performance guarantees are made to cover these extreme variations.

For example, consider the units at one plant with a contract rating of 36,000 hp, under 36 ft head, 75 rpm, with the runners submerged 15 ft below tailwater. This gives a specific speed of 161 and a sigma value of 1.32. These same units, however, are designed to give best efficiency when operating under 48 ft head, under which a maximum output of 42,000 hp is guaranteed. Under these conditions the runners are only 7 ft below tailwater, resulting in a sigma value of 0.82 and a specific speed of 121. Actually, when developing the 42,000 hp the units are operating at only approximately 75 per cent of their possible output. If it were feasible to operate under full-gate conditions at 48 ft head, they would probably develop in the neighborhood of 55,000 hp and would have a resulting specific speed of about 140.

The same comments apply to another unit, which is rated at 48,000 hp under 43 ft head but is designed to have its best efficiency when operating between 50 and 56 ft head. If the turbine developed unit horsepower under the 60-ft maximum head in proportion to its rating at 43 ft head, it would develop about 80,000 hp. Consequently, the sigma values are widely scattered, and only the minimum values shown can be considered as critical or limiting values.

In all cases, cavitation tests conducted on models of the turbines, including the complete draft-tube and scroll-case setting, have shown that the plant sigmas have a safety factor of from from 1 to 3 or 4 ft, and operating results to date have indicated the wisdom of using this additional margin to reduce pitting.

To bring out these points more clearly, we have plotted the curves shown in Fig. 2. Fig. 2(*a*) shows the specific speeds plotted against the rated heads for the seven propeller-type units and, for comparison, for three Francis-type units. Fig. 2(*b*) gives the distances that the center lines of the runners are below tailwater for the propeller-type units and above tailwater for three of the Francis-type units. The propeller turbines have runners set from 6 to 20.5 ft below tailwater, and the Francis-type units have runners set from 3 to 7 ft above tailwater. The circles represent the distances when considering the name-plate ratings of the units. The curve drawn through these points indicates that, at the higher heads, the runner should be set with less submergency, i.e., closer to the tailwater elevation. Actually, this is not the case, but because of the extreme fluctuation in tailwater levels of these plants, which operate at the low rated heads of from 36 to 65 ft, such results seem true. However, this curve should slope upward, i.e., the runner should be submerged a greater distance below tailwater when operating under the higher heads. This is proved by the dashed-line curve drawn through the crosses in Fig. 2(*b*). Each cross represents a mean value for head and submergency of runner below tailwater for all tailwater elevations in the cavitation guarantees for that unit. This curve slopes upward as it should.

Fig. 2(*c*) shows the horsepower of a 1-ft-diam runner at 1 ft head for the different Kaplan turbines. This set of points lies close together and indicates that for Kaplan runners, when the head increases from 36 ft to 65 ft, the allowable unit horsepower per unit of runner area decreases approximately 30 per cent. This, of course, agrees with the cavitation theory that the amount of water which can be put through a unit area of runner is limited so the energy in the water leaving the runner shall not be so great that, when regained by the draft tube, it will produce a vacuum approaching the theoretical perfect vacuum of 34 ft of water, less vapor pressure and altitude correction.

DRAFT-TUBE WATER-DEPRESSING SYSTEM

As mentioned previously, all propeller-type turbines are set with their runners submerged below normal tailwater. In order to save power when these units are operating as synchronous condensers to regulate voltage and correct power factor, we have installed water-depressing systems which lower the water below the runners, thus enabling them to revolve in air.

An air system, separate from the station-service system, with a 330-cfm compressor operating at 100 psi and with air storage varying from 2000 to 3500 cu ft, depending upon the volume of the draft tubes at each plant, is provided. The control diagram for one such system is shown in Fig. 3, a typical operation for which is as follows.

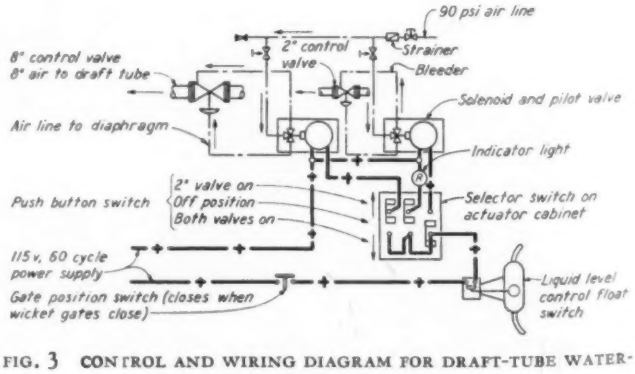


FIG. 3 CONTROL AND WIRING DIAGRAM FOR DRAFT-TUBE WATER-DEPRESSING SYSTEM

With the unit on load, when the control-room operator wishes to have a unit motored, he telephones to the governor attendant, who throws the two selector switches on the governor cabinet for both the 8-in. and 2-in. solenoid-operated diaphragm valves to the "on" position. The manual shutoff valve to the 8-in. air connection to the turbine to be motored is usually left open. The switchboard operator then backs off his load, and when the turbine gates reach the fully closed position the contact on the governor or turbine shifting ring closes, and both the 8-in. and 2-in. solenoid-operated air valves open. When enough air has entered the turbine to depress the water down to the level of the float valve near the draft-tube manhole, the float control switch opens and shuts off the air. The governor attendant then throws the selector switch on the governor cabinet which controls the 8-in. solenoid-operated valve to the "off" position. From then on, the 2-in. solenoid-operated valve admits the air under the regulation of the float control switch in the draft-tube tunnel to compensate for any leakage from the draft tube. When the operator wishes to pick up load, or the frequency drops, requiring the unit to pick up load, the governor interlock contact operates, thus shutting off the air. One wire of the electrical control circuit is carried through the wicket-gate position switch to prevent operation of this system if the wicket gates are open.

The usual time required to motor a unit is less than 1 min. Kilowatt input to the generator when motoring varies from 600 to 800 kw, depending upon the blade tilt for the Kaplan units.

DETERMINATION OF SCROLL-CASE AND DRAFT-TUBE OUTLINES

The usual procedure followed by the Authority in laying out the water passages in the powerhouse, that is, the intake, scroll case, turbine setting, and draft tubes is, first, to purchase the generating equipment and then give the turbine contractor a free hand within reasonable limits with regard to the hydraulic design of the water passages. Since the turbine contractor must guarantee the performance of his equipment from forebay to tailwater, including all losses, with the exception of trash-rack losses, in those passages, it seems reasonable that he should have some latitude in the design of those passages. Conditions at two of the main-river dams, however, made such a procedure impossible. On the moderate head development of this type, the powerhouse must form a part of the dam, and the intake structures must be completed to be self-supporting before water can be raised to allow navigation through the completed lock. For both of these projects, Congress had appropriated funds for the construction of a dam and lock without appropriating money for generating equipment. However, the growth of load on the generating system during 1940 and 1941 indicated that only a short time would elapse before generating equipment would be required in both plants.

Prior to this time, each of the three major builders of Kaplan-type turbines had different ideas as to the shape and relative dimensions of both the scroll-case and draft-tube passages. Two of these manufacturers had a strong preference for splitters in the draft tube. One manufacturer based his designs on a larger-diameter runner with lower water velocity. In order to proceed with the design of the substructure and to be able to complete the intake structure and enough of the powerhouse substructure to make the intake stable under full headwater pressures, it was necessary to get these manufacturers to agree on a compromise design on which they could all bid to advantage, and in which their machinery would operate, not only satisfactorily, but creditably after installation.

After considerable consultation, a tentative design was agreed upon which the three manufacturers felt would be reasonably satisfactory. This design gave each manufacturer certain leeway with regard to the height of wicket gates, the diameter of the stay ring, diameters of the runner, and the exact location and position of the nose pier at the small end of the scroll.

In order to satisfy all three manufacturers that their machinery could operate creditably under these conditions, a testing order costing approximately $3000 was placed with each one. This covered model tests of that manufacturer's turbine in the proposed setting. The designs had been so thoroughly discussed and agreed upon that all three of the manufacturers gave their unqualified approval to the turbine setting after completion of the model tests. At the present time, tests have been run on three of the units of one of these projects which are now in operation. These tests indicate that the units produce from 16 to 21 per cent more horsepower than the contract guaranteed. In addition to getting this added capacity, this coordination between the Authority and the contractors, in having the design agreed upon several months before funds were available, resulted in a saving of at least 8 months in the time required to put these units into operation.

MECHANICAL DETAILS

Because of the many and varied types of units involved, it is not our intention to discuss at length all the various features and mechanical details of the hydraulic turbines installed by the Authority. However, we shall give a description of the main items, and the Authority's practice in each case, together with a discussion of such features which are of particular interest.

(*a*) *Runners.* The Authority has adopted the practice of using cast steel as the metal for all heavily stressed parts, including the runner. The eight original 35,000-hp units at one plant are equipped with cast-iron runners, but the six new units, four now in operation and two being installed, are equipped with cast-steel runners. While the first cost of the cast-steel runners is greater, cast steel has the ability to resist shocks and avoid the tendency to crack and disintegrate after years of operation when subjected to fluctuating loads.

The recent failure of a cast-iron runner, which had been in operation in the plant of a utility company for about 12 years, substantiates the wisdom of this policy. Furthermore, cast steel has a much greater resistance to pitting and can be welded in a horizontal, vertical, or overhead position with either mild-steel or stainless-steel welding rod, without requiring preheating or stress-relieving, and without having to be drilled or tapped for studs on close centers as is almost a necessity when attempting to fill in pitted areas on cast-iron runners. While bronze is also an excellent metal to resist pitting on turbine runners, pitted areas can only be filled in by a brazing process in the vertical, or nearly vertical, position, and the entire casting must be preheated in order to achieve satisfactory results.

(*b*) *Guide Vanes.* Guide vanes are steel castings. When cast-steel guide vanes rotate in bronze bushings with grease lubrication, there is a tendency for the grease to be squeezed out on the loaded side of the bearing, and for corrosion or rusting to occur on these areas. Experiments have been conducted with various types of grease in an effort to find a lubricant which will adhere to the metal surfaces and which will resist any washing action of the water, but there is always some danger of corrosion of these parts. On the high-head turbines, we have found it advisable to add a sleeve or bushing shrunk onto the upper and lower guide-vane journals, as well as a stationary bushing in the head cover and discharge ring in which the guide-vane journals rotate. The sleeves on the guide-vane stems may be of stainless steel or of bronze, but if bronze is used a different grade of bronze from that used in the stationary guide-vane bushings in the head cover should be selected to prevent the scoring which always occurs when similar materials are used.

An interesting development is the use of chromium plating by the electrolytic process whereby a deposit of 0.005 in. thickness will be added onto the guide-vane stem and polished to form a corrosion-resistant journal. This will probably be

FIG. 4 CAST-STEEL THROAT RING AFTER SLIGHTLY MORE THAN THREE MONTHS' OPERATION

adopted on the turbines now being built because of the present war restrictions on stainless steel and bronze. The chromium used for electrolytic plating is obtained from low-grade chromium ores, which do not come under the restrictions applied by the War Production Board.

It has also been found advisable on the high-head turbines to apply a strip of corrosion-resistant steel to the top and bottom edges of the guide vanes where they move adjacent to the stationary parts, and also on the contact edges where adjacent guide vanes touch each other in the closed position.

All of the tributary plants of the Authority have large storage reservoirs, and the normal cycle calls for filling of these reservoirs between the period from January 1 to about June 15, the length of this period depending upon whether it is a wet or dry year. During this period, some of the storage plants will not produce any energy, but at least one unit in each of these plants will be kept floating on the line with guide vanes closed and with water in the scroll case, and with the governor set to open the guide vanes and pick up full load in from 5 to 8 sec in case of trouble on the transmission lines, or in case of a slight drop in frequency.

When high-head units are motored for a long period, there is bound to be a slight leakage both at the bottom and top of the guide vanes and where they contact each other in the closed position. This may cause erosion similar to a scouring action, or in some cases it causes actual pitting just downstream from the contact edges. On one 360-ft-head project, a strip of stainless steel about 2 in. wide is being welded on the top and bottom of the guide vanes and on the tip and on the large end of the guide vanes where they contact adjacent vanes in the closed position. On another high-head project now being built these areas will be chromium-plated, as the present restrictions prohibit the use of stainless-steel welding.

In the case of the Kaplan and propeller-type turbines, where the clearances between the ends of the guide vanes and stationary parts can be as much as $^1/_{16}$ in. or more without causing excessive leakage, it has been found satisfactory to paint these surfaces in order to prevent rapid corrosion of the finished steel.

(*c*) *Scroll Cases.* Scroll cases on the low-head main-river plants are concrete. The high-head storage plants on the tributaries have riveted-plate-steel scroll cases of the conventional type, except in one station which has cast-steel scroll cases, and in another which will have welded-steel scroll cases.

(*d*) *Throat Rings on Kaplan or Propeller Units.* Rolled plate steel has shown itself materially better for pitting resistance than cast steel. In one plant containing four duplicate units, two of the units are equipped with cast-steel throat rings, the other two are equipped with plate-steel throat rings of welded construction. After 2 years of operation, the cast-steel throat rings had pitted from $^1/_8$ to $^1/_2$ in. deep completely around the ring and approximately 10 in. in height. After $1^1/_2$ years of operation, the plate-steel throat rings are still in perfect condition. In another plant where all the throat rings are of welded rolled-steel construction, there is no evidence of any pitting or erosion after 3 years of operation. The Authority's present practice is to specify rolled-steel welded-type throat rings on all Kaplan- and propeller-type turbines, but with the restrictions of the use of heavy rolled-steel sections, manufacturers have had to change over to cast-steel throat rings on two of the turbines. Since the lower part of the throat ring has a spherical shape to fit the curved periphery of the runner blades, plates 4 to 5 in. in thickness are required, and these are difficult or impossible to get under present war conditions.

(*e*) *Guide Bearings.* The units in the main-river plants all have water-lubricated main turbine bearings. Two of these units are equipped with lignum-vitae bearings of the adjustable type. Two are of the rubber-lined nonadjustable type and the balance, which are in the majority, are of the "Insurok" adjustable type. In all cases the Insurok strips are wedged into adjustable shoes which can be adjusted to take up the wear. The bearing surface on the shaft in all cases is stainless- or a high-chromium corrosion-resistant steel sleeve, either pinned or clamped on the shaft with keys.

All of the 12 units in the storage or tributary plants have oil-lubricated babbitt-lined bearings working directly on the polished steel of the main shaft. No sleeves are required in these bearings, although corrosion-resistant sleeves are used in the stuffing box below the oil-lubricated bearings. The lubricating system on all these bearings consists of one alternating-current- and one direct-current-motor-driven circulating pump. Under normal operation, the alternating-current-driven unit does the work, with the direct-current battery-operated unit as a reserve, but ready to come into operation in case of low flow or low pressure on the oil-circulating system. An oil reservoir in the head cover is provided for the oil leaving the bearing and gives sufficient cooling to prevent overheating of the oil.

(*f*) *Shaft.* All shafts are open-hearth carbon- or alloy-steel forgings, heat-treated, and smooth-machined finish. They are fitted with renewable sleeves where they pass through the water-lubricated guide bearing and the stuffing box in the head cover. All are hollow-bored and given internal inspection to detect any flaws or cracks.

GOVERNORS

Governing systems for all turbines are of the relay-valve "actuator" type with motor-driven governor head, complete auxiliary control mechanisms, restoring mechanisms, oil-pressure system, piping, and, in the case of the Kaplan units, the control valve for runner-blade adjustment. They are of the cabinet type, i.e., with all governing mechanism mounted in one cabinet. Governors for either one or two units are mounted in one single or double cabinet as the powerhouse arrangement dictates.

Gate-operating time, as controlled by the governor, varies from a minimum of 4 sec to a maximum of 12 sec for the various units. Speed-level controls are set to adjust the speed of the turbine from 85 per cent of rated speed at no load and zero speed droop to 105 per cent of rated speed at full load and maximum speed droop. Speed-droop adjustment is specified to be from zero to 6 per cent speed droop from zero gate to full opening, respectively.

The governing systems are designed for a pressure of from 250 psi minimum to 300 psi maximum, but tests on units already installed indicate that a pressure of less than 200 psi is required to operate the wicket gates. The extra pressure allows a margin for closing down in case of failure of the motor-driven pumps.

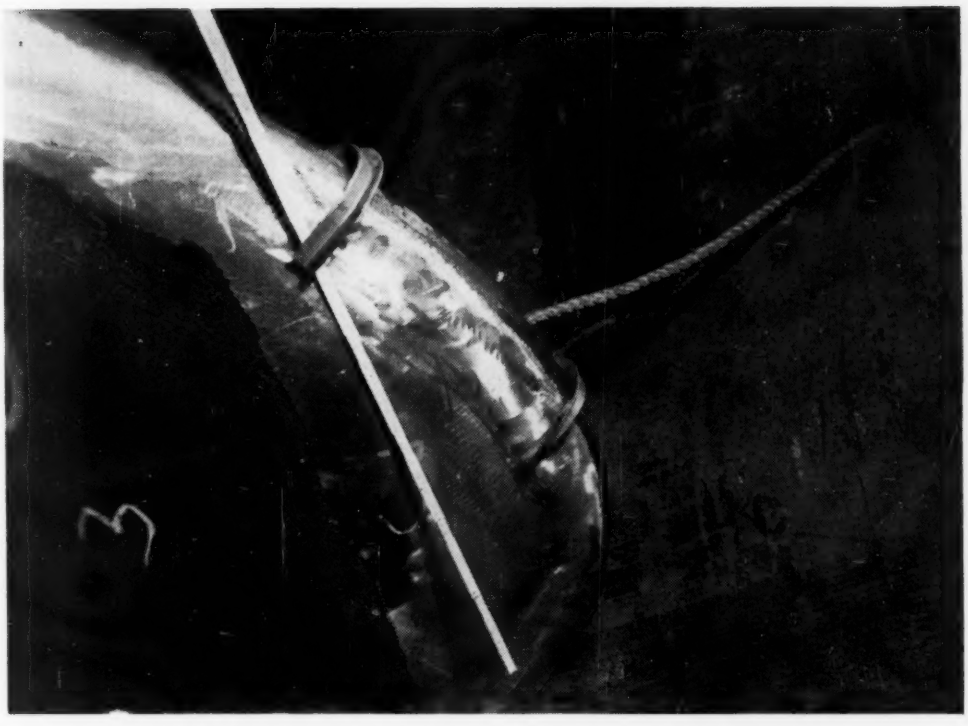


FIG. 5 TURBINE BLADE SHOWING CAVITATION ON UNDERSIDE

METHODS OF PREVENTING CAVITATION

The Authority's experience indicates that, while no manufacturer has been able to eliminate it entirely, pitting in the turbine runners and stationary parts can be materially decreased, or nearly eliminated, by observing carefully five major points in design and operation:

1 The turbine runner must be set with proper relation to normal tailwater, and for this purpose careful cavitation tests on a model are desirable, not only on Kaplan units and propeller-type units, but also on Francis-type units. Such tests give accurate information from which to judge the safe operating limits, both for limiting the horsepower of the unit under critical tailwater conditions and for determining the proper setting of the runner with relation to tailwater when designing the plant.

2 The turbine parts and the water passages must be properly designed. The major responsibility for this item lies with the manufacturer who must watch the location of the guide-vane pivots with respect to the diameters of the runner so the tips of guide vanes do not overhang the runner sufficiently to cause pitting. He must watch the curve of the throat ring, as too sharp a curve will result in disturbances which induce cavitation. He must watch the shape and taper of the wicket gates and, in many cases, must reduce the thickness or taper them toward the bottom edge in order not to leave voids in the stream of water entering the runner. He must also watch the clearances between the runner and the throat ring, and the curve of the throat ring and the lower part of the runner, so as to strike the proper balance between efficiency, pitting, and cost in the design of these parts.

3 Suitable materials must be selected. As just discussed, welded-plate-steel throat rings offer a great deal more resistance to pitting than cast-steel throat rings. Fig. 4 shows one of the cast-steel throat rings on a Kaplan runner turbine after slightly more than three months' operation. The pitting starts approximately at the center line of the runner and extends diagonally downward about six inches following the path of the water. This excessive pitting, after only three months of operation, was traced to the $^1/_{64}$-in. offset between the horizontal joints of the upper and lower sections of the throat ring caused by improper handling of the parts either during shipment or erection. In one or two other cases pitting has been aggravated to a large extent by an obstruction or a small burr on this horizontal joint.

4 Suitable protection must be provided by the use of stainless steel and other corrosion-resistant metals. The practice of prewelding under critical areas on the edges and lower surfaces of the runners appears to offer adequate protection, but, even so, cast steel should be used in preference to cast iron so that additional areas can be repaired by welding before pitting becomes dangerous.

Fig. 5 shows the area on a Kaplan running blade which has been prewelded with stainless steel. This photograph also shows the pitted area on the bottom side of the blade after 12 months of operation at practically fullload. This pitted area was welded with stainless-steel rod before the unit was put back in service. One year's additional service showed practically no additional pitting, and the stainless surfaces remained perfect.

5 Operations must be within judicious limits as to capacity and heads, based on the information obtained in the cavitation tests on the model, and from vibration or noise tests on the actual installation. In some instances, it has been found impractical to set the turbine low enough to allow for full-gate operation under conditions of low tailwater. Under these conditions, which may occur one or two weeks during the end of the draw-down period, it has been found necessary to reduce the output of the turbine to loads which the model tests indicated were within the cavitation limits. In many cases, it has been found that the turbine can develop 10 or 20 per cent

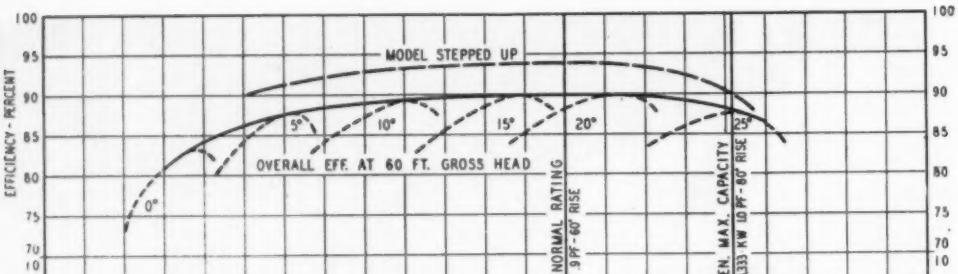


FIG. 6 OVER-ALL EFFICIENCY AND DISCHARGE CURVE FOR TYPICAL KAPLAN PROPELLER UNIT

above the rated capacity, especially where the units are subject to considerable variation in head. In some cases also, it is possible to utilize this capacity without overheating the generator. Sometimes these overloads produce vibration and other disturbances which indicate that cavitation is occurring in some part of the turbine. By maintaining the output just below the point at which these noises and vibrations become objectionable, cavitation and pitting can be materially reduced.

TURBINE-ERECTION PROCEDURE

In an organization as large as the Tennessee Valley Authority, which has several hydroelectric plants being built at the same time, there are apt to be as many different methods of erection as there are plants being built. In an effort to standardize on some of the more important items of erection of a turbine, a turbine-erection specification is written for each plant. These specifications are drawn up in their preliminary form by the Authority's Design Department. The preliminary forms are sent to the turbine manufacturer, the generator manufacturer, and to the field forces who will erect the machines, for their comments and views on the procedures as set forth. When these comments have all been received, the specifications are put in their final form and copies delivered to all parties concerned. The purpose of these specifications is to familiarize every one concerned with what is to be done in the erection of a machine. They are also intended to serve only as a convenient summary of standard field-erection practice but do not attempt to preclude alternate methods of accomplishing the desired results. These specifications deal in detail with four major items, namely, the embedded parts, the internal stationary parts, the internal rotating parts, and the machine alignment and tolerances.

It has been found necessary to take certain precautions in placing the concrete around the embedded parts to avoid distortion. The pours are limited around some of the embedded parts to 1 ft of height per hr. The total depth of some pours is limited in height from 2 to 6 ft, depending upon location. It has also been found advisable to place the pours around the circumference of the embedded parts in such a manner that they are approximately diametrically opposite. The use of mechanical vibrators is restricted in certain pours where alignment of the embedded parts might be affected. Vent and drain holes are provided where necessary to prevent trapping air or water.

The portion of the specifications concerning the internal parts of the turbine, both rotating and stationary parts, deals mainly with the sequence of erection, and the method of aligning these parts in order to avoid any unnecessary placing and removing of certain pieces.

The machine-alignment and tolerance items of the specifications are interspersed throughout its entire length. Prior to placing the initial embedded piece, the unit control lines are established, and from these lines the first piece is located and embedded. Once this piece is fixed, the control lines are forgotten and the remaining parts are located from it. A heavy plumb bob suspended by piano wire from a tower is immersed in a container of heavy oil. This piano wire is located in the center of the first embedded part, and each succeeding piece, whether embedded or internal, is located with reference to this wire as it is installed. Once the stay ring is installed, all elevations are taken from the machined surface of this piece, since all other pieces are referred to it by definite dimensions. The connection between the runner and the shafts and the connection between the two shafts are covered in detail, especially regarding the stress introduced in the coupling bolts. All bolts in any one coupling are stretched the same amount. This stretch in the bolts is computed to give a stress approximately 25 per cent greater than any possible loading to which they may be subjected.

The alignment of the combined shafts has been standardized for every installation. The procedure of aligning is mainly as follows: A 360-deg-rotation check is made in four stages, and the shaft is checked from fixed tram points at a minimum of two different elevations at each 90-deg position. When the throwout of the shaft has been determined, the center of this throwout circle is set vertically under the center of the top point checked. The generator guide bearing and the turbine guide bearings are set up about this vertical line.

EFFICIENCY AND INDEX TESTS

To date the Authority has made actual efficiency tests only on two 66,000-hp turbines installed at one plant. These tests were made by the Gibson method, and the results indicated that for both units the actual efficiencies were from 2.1 to 3.9 per cent above contract guarantees.

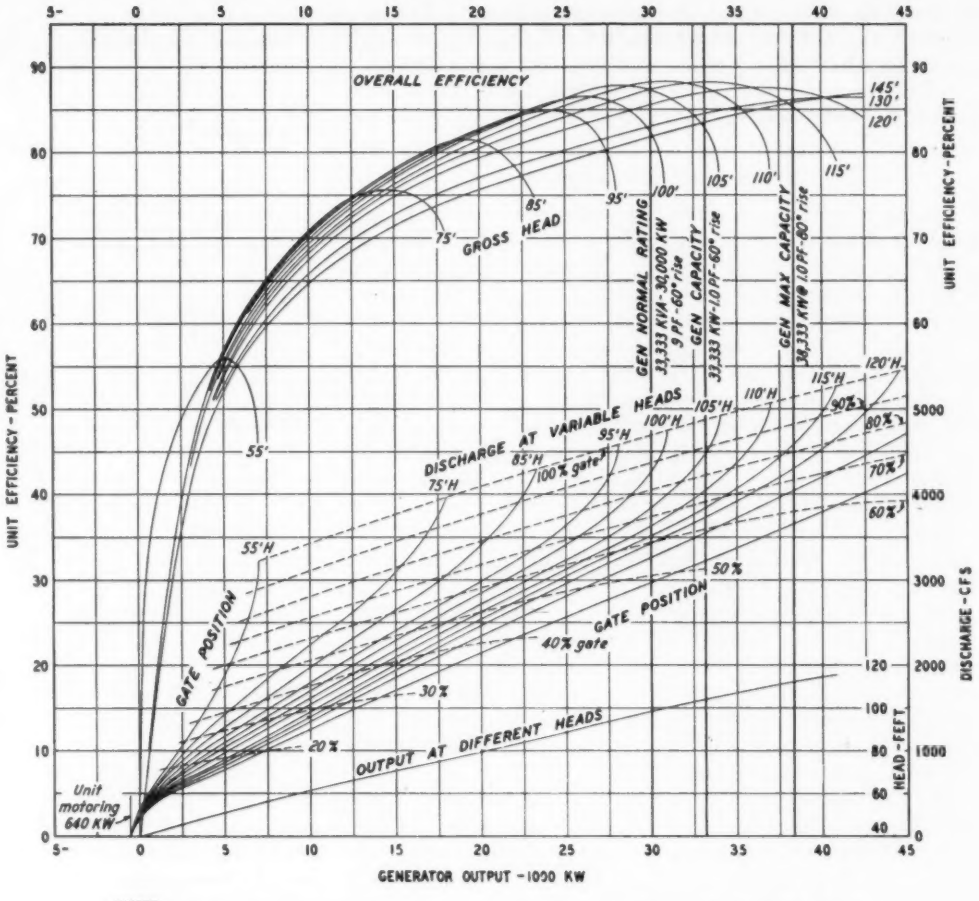
Provisions have been made so that efficiency tests can be made on all tributary plants, which are high-head projects, after the present war emergency is over. These provisions take the form of piezometer connections as used for the Gibson test. The piezometer connections are usually made to a straight section of the intake pipe approximately 100 ft long, with the lower set of taps being some 5 to 20 ft upstream from the turbine intake.

In the case of the main-river plants, it is not planned to run efficiency tests because of the cost and relative difficulty involved in such measurements, and to the somewhat questionable results which would be obtained due to the error involved in determining the water flow because of the short water passages. For these units, the efficiencies are determined by a model test conducted in a laboratory. The Moody formula has been adopted for converting the model performances into

the actual performances of the prototype. The usual practice is to apply the correction computed for the peak of the efficiency curve to the remaining portion of the curve. By referring to Fig. 6, it will be seen that the efficiency curves of both the model and the prototype are essentially parallel, which bears out this assumption. Note the flat curve with consistently high efficiencies over a wide range of load. This, of course, is characteristic of adjustable-blade turbines, such as are installed at this plant.

On all plants, capacity tests are made to determine the actual output of the turbine at various heads. If actual efficiency tests have been made on the generators prior to the capacity test, then the actual generator efficiencies are used in computing the turbine output. If the tests have not been made on the generators, then the manufacturer's guaranteed efficiencies are used for all computations.

An index test is made on each unit in each plant on both the tributaries and the main river. These tests serve the purpose of determining the relative performances of each individual turbine at different heads, loads, and gate openings. For these tests, a set of taps of the Winter-Kennedy type is provided in the scroll case. One tap is located on the outside of the scroll case, the other three are located on an inside radius on or near the speed ring. These tests are based on differential pressures. Water columns are used to obtain the differential pressures in plants having heads up to 150 ft. In plants with heads above 150 ft, mercury columns are used. For obtaining the kilowatt output of the generators, a stop watch is used to measure the time of the revolving disk in the watthour meter located on the main switchboard. From the data obtained during the tests, a calibration is obtained on the Winter-Kennedy taps, two of which are later connected to the turbine flowmeter located on the actuator board, so that the discharge for each individual turbine can be recorded on the powerhouse operator's daily log sheets.


OVERALL EFFICIENCY
GROSS HEAD
GEN NORMAL RATING 33,333 KVA-30,000 KW 3 PF-60° rise
GEN CAPACITY 33,333 KW-1.0 PF-60° rise
GEN MAX CAPACITY 36,333 KW @ 1.0 PF-60° rise
DISCHARGE AT VARIABLE HEADS
GATE POSITION
OUTPUT AT DIFFERENT HEADS
Unit motoring 640 KW
UNIT EFFICIENCY - PERCENT
UNIT EFFICIENCY - PERCENT
DISCHARGE - C F S
HEAD - FEET
GENERATOR OUTPUT - 1000 KW

NOTES:
The following cavitation guarantees should be observed during the first year of operation in order not to void the guarantees.

HEAD-FEET	OUTPUT HORSEPOWER MINIMUM Not more than 800 hours	OUTPUT HORSEPOWER MAXIMUM Do not exceed for more than 50 hrs altogether
146	20,000	50,000
125	20,000	50,000
110	20,000	49,100
100	20,000	41,500
75	20,000	23,000
55	8,500	9,000

Based on experience curves furnished by S Morgan Smith Co. revised from data obtained from index test on unit 1 on 4-17-42. Data should be revised to include other field tests of turbine & generators.
TURBINES RATED:
41,500 HP-100' head-94.7 RPM-manufactured by S Morgan Smith Co. York, Pa.
GENERATOR RATED:
33,333 KVA-3 phase-60 cycles-13,800 volts-.9 power factor-60° rise 94.7 rpm. manufactured by General Electric Co., Schenectady NY.

FIG. 7 OPERATING CHARACTERISTICS OF TYPICAL FRANCIS RUNNER 33,333 KVA

Based on the assumption that the combined efficiencies of the turbine, the generator, and the water passages including the penstocks would give an over-all efficiency of 88.5 per cent under a gross head of 115 ft, the curves in Fig. 7 were constructed. These curves, which are for a Francis runner, show the relative efficiency of this turbine over the extreme head variations from 145 ft down to 55 ft. As other heads are obtained, additional index tests will be made to check or correct the curves in the region of both the extremes in the head variations.

The index tests on the main-river plants serve four major purposes; three being the same as those on the tributary plants, and the fourth being the shaping of the cams which adjust the tilts of the runner blades to the most efficient blade angle for any given gate opening. Fig. 6 shows the over-all efficiency, output, and corresponding discharges of recent tests on a Kaplan runner. This curve is based on the assumption that the combined efficiencies of the turbine (from model test), the generator manufacturer's guarantee, and the water passages would give a maximum over-all efficiency of 90 per cent under a gross head of 60 ft. The individual blade-angle curves at each 5 deg (shown dotted on the chart) were obtained by blocking the runner blades in a fixed position and varying the gate openings to obtain readings over the peak-efficiency range of each individual blade setting. The peaks of these individual curves represent the maximum over-all efficiency which can be obtained with that particular blade setting and the correspondingly correct gate opening. The envelope curve, drawn through the peaks of each of these individual curves, represents the best over-all gate-blade relation. Therefore, the cams which control the blade angles are shaped to give this relation. After the cams have been shaped, a new set of data is obtained

to check the shape of the cam as altered. For the last unit checked, the cam as altered checked the theoretical shape within less than 0.25 per cent.

All of the units the Authority has tested to date have exceeded the manufacturer's horsepower and efficiency guarantees.

FEATURES OF THE EMERGENCY PROGRAM

During the summer of 1940, it became evident that the war program of the United States would require additional power at the earliest possible moment. A large amount of this power was to be needed in an area where large aluminum producers were expanding their plants.

Accordingly, Congress authorized a high-head tributary project on July 31, 1940. By concentrated effort, the engineering department completed the plans, and the construction department completed the construction, so that the first unit went into operation in April, 1942, or 20 months after the project was authorized. At the time, this constituted a record for a hydroelectric project of this magnitude.

The entry of the United States into the war, in December, 1941, created a demand for large blocks of additional power for war production. To obtain this power, Congress authorized another high-head tributary project, and the first unit of this plant has gone into operation in less than 13 months after the project was authorized. This world's record for such a construction project was achieved by the close co-ordination of the responsible departments of the Authority in adapting and translating the design and construction problems of the first project to those of the second project.

The units at the first project are rated 41,500 hp at 100-ft head and 94.7 rpm, and they operate between 55- and 145-ft head. In January, 1942, with one unit practically installed and the second unit delivered and ready for installation, the question arose as to where the additional power could be obtained in the shortest time. While this plant was laid out for an initial installation of three units, two units can develop most of the firm power if operated on a base load carrying full load 168 hr per week. The second project, then only in the investigation stage, offered a site where the head varies from 65 to 130 ft, with an average close to 100 ft at which the turbines of the first project are rated. The drainage area at the second project is approximately 30 per cent greater, the average stream flow approximately 60 per cent greater, but the storage volume is only 70 per cent of that at the first project.

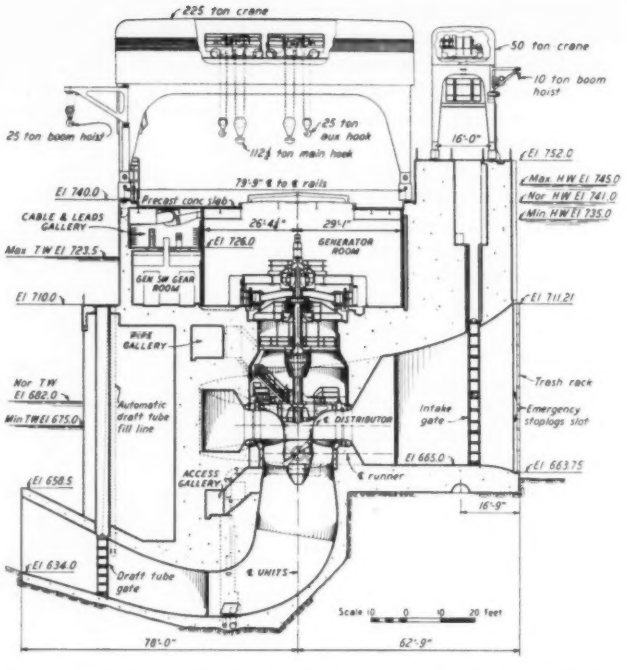


FIG. 9 SECTION THROUGH TYPICAL POWERHOUSE WITH KAPLAN RUNNER

These conditions made it feasible to use the identical generating equipment and to duplicate the entire first development at the second project site. While some designing was necessary because of topographic differences, it may be said that the powerhouses of the two projects will be practically duplicates. In most cases identical drawings were used.

Consequently, the third unit for the first project was stored in the yard from February, 1942, to September, 1942, by which time construction at the second project had progressed sufficiently to allow the installation of the unit at that plant.

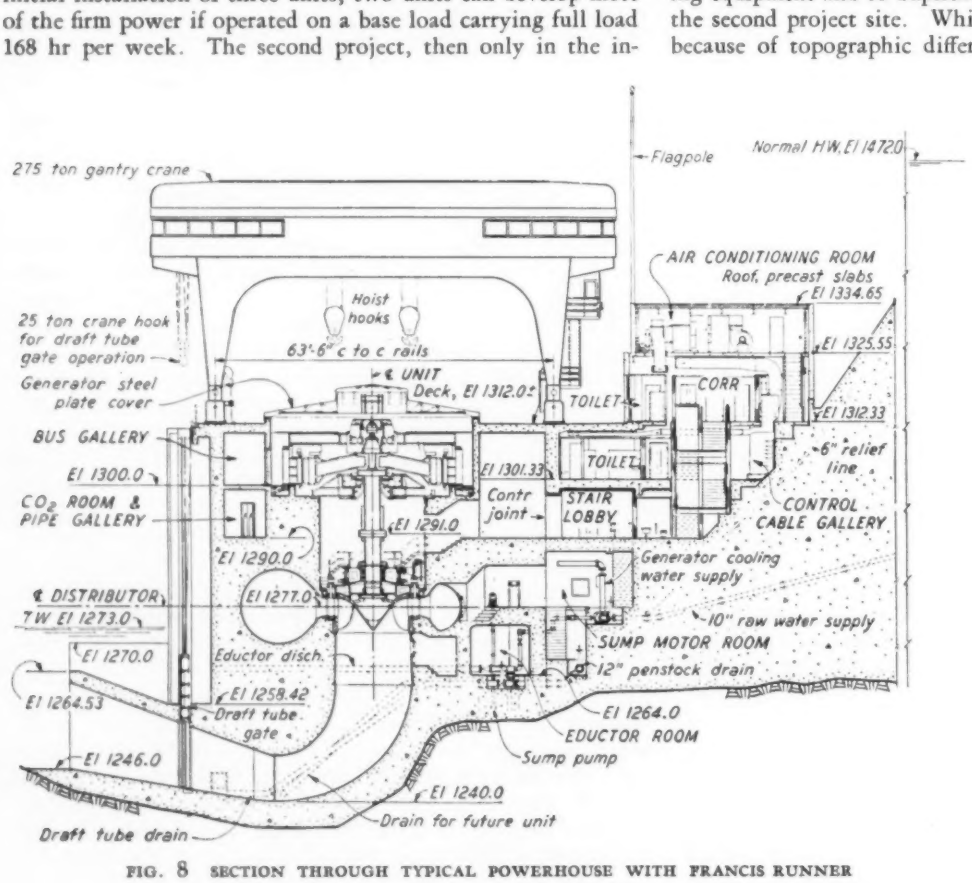


FIG. 8 SECTION THROUGH TYPICAL POWERHOUSE WITH FRANCIS RUNNER

ACKNOWLEDGMENT

All engineering and construction work of the Authority is under the direction of Col. T. B. Parker, chief engineer. S. M. Woodward is chief water-control-planning engineer, A. L. Pauls, chief construction engineer, and George R. Rich, chief design engineer.

The authors acknowledge the aid of Messrs. C. L. Norris, R. M. Gardner, and J. R. Parrish in preparing data and charts and in doing research work in the preparation of this paper.

ADVANCES *in* PLASTICS *During* 1942

By G. M. KLINE

NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

PLASTICS had a rendezvous with war in 1942. How well they proved their mettle during that first encounter with a market stripped of all decorative and novelty appeal and calling for cold utility and unfailing performance under fire will be evident from the facts presented in this review.

PRODUCTION OF PLASTICS

Statistics released during the year indicated that the production of plastics during 1941 was more than 57 per cent greater than in 1940. Because of restrictions on manufacture and uses of most all types of plastics, the same rate of growth may not have been maintained during 1942. However, the statistics will probably show that the industry's production in 1942 doubled that of 1940, just as 1941 doubled that of 1939. The total production of resins reported in 1941 was about 438,000,000 lb and that of cellulose plastics was 33,400,000 lb, which together with unreported materials established an industry record at about the 500,000,000-lb figure (1).[1]

Because of the difficulties in obtaining equipment for new plants, there was little activity in the marketing of new materials. One outstanding development, a thermosetting transparent resin which polymerizes without the evolution of water, and hence is especially adapted to low-pressure molding, was reported (2). This resin is considerably more resistant to scratching than other types of transparent plastics. Its chemical identity has not been disclosed, so that it is known only by the trade name "Columbia Resin 39."

Several articles were published which described improvements in the formulation of molding compounds with various fillers and plastic binders. These pertained to compositions containing walnut-shell flour (3), styrene plasticized with chlorinated diphenyl for high-frequency work (4), sisal fiber (5), mica and lead borate (6), cord-filled phenolic (7), and aniline-formaldehyde resin (8).

The effect of restrictions in the use of synthetic resins was reflected in the number of reports describing plastic compositions made from noncritical raw materials, generally of natural origin. These dealt with the use of lignin (9, 10, 11, 12), bagasse (13), rosin (14), and related substances (15, 16), redwood fibers (17), and miscellaneous hydrocarbons (18, 19). The use of agricultural by-products as sources of raw materials for plastics was discussed in two papers (20, 21).

The swelling properties of various fillers in water and alkali solution were reported (22).

MOLDING AND FABRICATING

Injection-molding of thermosetting plastics made rapid strides during 1942. The basic characteristic of this new process is the introduction into the material of all the heat load required for polymerization prior to injection into the mold which shapes and sets the plastic. It is reported to provide parts of uniform density and excellent quality on fast production schedules and to be especially adapted to molding parts with inserts (23).

Further progress was made in the utilization of low-pressure molding methods in the fabrication of relatively large parts for aircraft and other military purposes. Several reviews of the problems and advantages of this technique were published (24, 25, 26), and an important patent relating to the field was granted (27). The urea-formaldehyde resins continued to predominate as the bonding agent for production in this field, but there was considerable activity in the development of phenolic resins which would be suitable for use at low temperatures and pressures. Reference has already been made to the adaptability of the Columbia resins to low-pressure molding.

The use of zinc alloys for casting molds which are suitable for short runs on plastic parts was described (28). Availability of these molds at the present time is restricted to high priority needs because of shortages of the alloying elements, aluminum, copper, and magnesium. A report appeared concerning the effects of annealing conditions on the hardness of mold steels (29).

APPLICATIONS

The normal market of the plastics industry was "blitzed" by the military during 1942. However, it was an attack in which the industry co-operated fully and the record shows a rapid and effective conversion of materials and molding facilities to production for war. Ordnance components molded of plastics included handles for pistols, bayonets, and machine guns (30), fuse parts (31), ammunition rollers (32), and booster tubes (33). Quartermaster-supply items fabricated from plastics included helmet liners (34, 35), whistles (36), bugles (37), skis (38), and raincoats (39). Chemical-warfare services utilized plastics extensively in gas masks (40, 41). The battle fleets employed plastics in navigation instruments (42), wire and cable insulation (43, 44), binoculars (45), and tableware (46). Small landing craft and swift patrol boats were made of resin-bonded plywood (47, 48). Goggles (49), wire-reinforced flexible window enclosures (50), parachute-flare bases (51), and stirrup pumps (52) were among the miscellaneous war products in which plastics were used.

The background of experience in these applications of plastics and the accumulation of results of experimental and service tests on various plastic parts can be expected to lead to an even more amazing array of diverse military applications of molded plastics during 1943.

The aircraft industry utilized plastics on an expanding scale for many such parts which have become standard accessories. Reports of developments in masts (53), dies for forming metal sheets (54), fairleads (55), pilot seats (56, 57), radio-loop housings (58), and propellers (59) were published. Plastic plywood was employed in the construction of trainers (60, 61), gliders (62, 63), and miscellaneous structural parts and accessories (64, 65, 66, 67, 68).

Developments in plastic plywood for use in building construction (69) and a variety of direct war applications (70, 71, 72) were described. Improvements in the resinous impregnating

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Rubber and Plastics Group of the Process Industries Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

and bonding agents employed in this field were reported (73, 74, 75).

Reviews were published pertaining to the applications of plastics in marine bearings (76), water-meter disks (77), name plates (78), closures (79), collapsible tubes (80, 81), and printing plates (82). Experimental studies on plastics for lighting fixtures (83) and dentures (84) contributed materially to better practice in these specialized fields.

There were two significant reports on the development of elastic plastics to replace rubber in some of its miscellaneous applications (85, 86). More emphasis can be expected to be given to these elastic plastics in 1943.

Another noteworthy feature of the literature of 1942 is the occasional consideration given to postwar applications of plastics. These articles included discussions of shipbuilding (87), home construction (88, 89), and design of industrial products (90, 91), as well as postwar competition of plastics with metals (92). A patent was granted to Henry Ford for an automobile body fabricated from plastics (93). Further constructive planning of this sort during 1943 will enable the plastics industry to take the eventual transition from war to peace in a stride worthy of a progressive and growing industry.

PROPERTIES, TESTING, AND SPECIFICATIONS

There was a gratifying increase during 1942 in the number of published papers setting forth the results of investigations of the mechanical properties of plastics. Many more engineering data of this type are needed to utilize plastics effectively in the military and postwar industrial fields. Committee D-20 on Plastics of the American Society for Testing Materials and the Rubber and Plastics Group of this Society have been very active in promoting the preparation and distribution of these reports. The co-operation of all research and testing laboratories in the industry is needed further to augment our basic knowledge of the properties of plastics.

Four papers concerning various properties of plastics were presented at the 1942 Annual Meeting of the American Society for Testing Materials. One of these (94) gave data for the tensile, flexural, and impact strengths of phenolic molding compounds over the temperature range of —80 to 225 C (—112 to 437 F). Another described experimental work on the determination of the mar resistance of various types of plastics (95). Further work at the University of Illinois on the properties of cellulose-acetate plastic was reported (96); this portion of the investigation was concerned with the effect of time on the deformation of the cellulose-acetate material when subjected to constant tensile loads for periods of time up to about 10 months. The effects of acids and alkalies of various concentrations on different types of plastics were determined by means of a shear-strength test in the fourth paper of this group (97).

Six papers relating to plastics were presented before the Rubber and Plastics Group of The American Society of Mechanical Engineers during 1942. The bearing strengths of paper- and fabric-base phenolic plastics were compared with birch plywoods after conditioning the specimens at 160 F, 70 F, and 50 per cent relative humidity, and 70 F in water, respectively (98). Another report described the behavior of plastics under sustained vibrations from a new oscillatory-type testing machine in tension, compression, and torsion (99). The physical properties of new types of laminated plastics are tabulated in a third paper (100). Information regarding the strength properties of plastic plywood employed in the fabrication of aircraft structural parts is presented in another report (101). The two remaining papers have not yet been published. One (102) presents information regarding the effects of heating for periods up to 3 weeks at temperatures ranging from 110 to 225 C. The other (103) supplements information previously published on the mechanical strength and fatigue properties of cellulose acetate, based on work conducted at the University of Illinois.

A number of other papers dealing with various mechanical properties of plastics were published during 1942. These related to the influence of temperature on the properties of polystyrene (104), the effect of solvents on plastics as determined by reduction in shear strength (105), impact strength (106,107), flow properties (108), and bending fatigue (109).

Eight new tentative standards (110), prepared by Committee D-20 on Plastics of the American Society for Testing Materials, were adopted during 1942. The titles of these are as follows:

1 "Repeated Flexural Stress (Fatigue) Test of Plastics" (D671-42T).

2 "Test for Haze of Transparent Plastics by Photoelectric Cell" (D672-42T).

3 "Test for Mar Resistance of Plastics" (D673-42T).

4 "Long-Time Tension Tests of Plastics" (D674-42T).

5 "Terms and Descriptive Nomenclature of Objects Made From Plastics" (D675-42T).

6 "Method of Test for Compressive Strength of Plastics" D695-42T).

7 "Method of Test for Coefficient of Linear Thermal Expansion of Plastics" (D696-42T).

8 "Method of Test for Water Vapor Permeability of Plastic Sheets" (D697-42T).

The Specifications Subcommittee of Committee D-20 prepared tentative specifications for phenol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, polystyrene, cast methyl-methacrylate, cellulose-nitrate, and rigid vinyl-chloride-acetate plastics. Preliminary drafts for cellulose-acetate, cellulose-acetate-butyrate, and laminated phenolic plastics were circulated for comment and are expected to be adopted as tentative standards early in 1943. At the request of several government departments, a joint committee of representatives of the American Society for Testing Materials, the Society of Automotive Engineers, and of the Army and Navy was organized in December as Section 10 of the A.S.T.M. Plastics Specifications Subcommittee to prepare specifications for the nonrigid plastics. Included among these are the elastic-vinyl, polyacrylate, and ethyl-cellulose plastics.

BIBLIOGRAPHY

1 "Plastics Statistics for 1941," *Modern Plastics*, vol. 20, Sept., 1942, pp. 86–87.

2 "New Thermosetting Compounds," *Modern Plastics*, vol. 20, Oct., 1942, pp. 88–90, 120, 122.

3 "Walnut-Shell Flour," by E. F. Lougee, *Modern Plastics*, vol. 19, Feb., 1942, pp. 19, 35–37, 100, 102.

4 "Styramic for High-Frequency Insulation," by T. S. Carswell and R. F. Hayes, *Modern Plastics*, vol. 19, Feb., 1942, pp. 68–70, 108.

5 "Molding a Phenolic-Sisal Product," by H. C. Nelson, Jr., and L. D. Reed, *Modern Plastics*, vol. 19, Mar., 1942, pp. 52–53, 90.

6 "Injection-Molded Mycalex," by T. N. Willcox, *Modern Plastics*, vol. 19, Apr., 1942, pp. 54–55, 118, 120.

7 "High Impact Molding Compounds," by C. H. Whitlock and R. U. Haslanger, *Modern Plastics*, vol. 19, June, 1942, pp. 70–71.

8 "Dilectene—A New Insulating Material," by S. A. Rulon, *Modern Plastics*, vol. 19, June, 1942, pp. 72–74.

9 "Wood Hydrolysis; A Continuous Process," by R. Katzen and D. F. Othmer, *Industrial and Engineering Chemistry*, vol. 34, Mar., 1942, pp .314–322.

10 "Lignin-Plastics Development," *Modern Plastics*, vol. 19, May, 1942, pp. 46–47.

11 "Lignin-Enriched Filler," by John G. Meiler, *Modern Plastics*, vol. 20, Sept., 1942, pp. 64–66, 128, 130.

12 "Plastics From Hydrolyzed Lignocellulose," by R. Katzen, A. O. Reynolds, and D. F. Othmer, *Modern Plastics*, vol. 20, Oct., 1942, pp. 91–97, 122, 124.

13 "Bagasse Molding Compounds," by T. R. McElhinny, *Modern Plastics*, vol. 20, Nov., 1942, pp. 64–65, 136.

14 "Woodpulp Plastic Products," by A. W. Uris, *Modern Plastics*, vol. 19, July, 1942, pp. 53–54, 116.

15 "Vinsol Resin-Extender and Modifier," *Modern Plastics*, vol. 19, June, 1942, pp. 59, 102.

16 "Priority-Free Pipe," by H. W. Richter, *Modern Plastics*, vol. 20, Sept., 1942, pp. 48–49.

17 "Molding With Noncritical Materials," by C. P. Morgan, *Modern Plastics*, vol. 20, Nov., 1942, pp. 60–61.

18 "Naftolen—Its Use in Plastics and Coatings," by L. Bornstein and F. Rostler, *Modern Plastics*, vol. 19, Apr., 1942, pp. 72–74, 122.

19 "Hardwood Pitch Extender," *Modern Plastics*, vol. 20, Nov., 1942, pp. 112.

20 "Plastics From Agricultural Materials," by O. R. Sweeney and L. K. Arnold, Iowa Engineering Experiment Station, Bulletin No. 154, 1942.

21 "Cottonseed Meal in Phenolic Plastics," by F. Rosenthal, *Industrial and Engineering Chemistry*, vol. 34, Oct., 1942, pp. 1154–1157.

22 "Fillers: Swelling Properties and Structure," by R. J. Kent and J. Seiberlich, *Modern Plastics*, vol. 19, June, 1942, pp. 65–69, 102.

MOLDING AND FABRICATING

23 "Injection Molded Thermosetting Parts," by A. R. Morse, *Modern Plastics*, vol. 20, Nov., 1942, pp. 41–43, 128, 132, and 134.

24 "Low-Pressure Laminating," by J. D. Nelson and G. F. D'Alelio, *Modern Plastics*, vol. 20, Sept., 1942, pp. 45–47, 122, 124.

25 "Molding Plastic Plywood," *Modern Plastics*, vol. 19, July, 1942, pp. 46–49, 112, 113, and 116.

26 "Advances in Production and Assembly of Plywood in Aircraft Construction," by H. G. Bersie and E. R. Clarke, *Aeronautical Engineering Review*, vol. 1, July, 1942, pp. 13–15, 17, 19.

27 "Method of Forming Veneer Structures," by E. L. Vidal and L. J. Marhoefer, U. S. Patent 2,276,004, Mar. 10, 1942.

28 "Zinc Alloys for Molds," by J. Delmonte, *Modern Plastics*, vol. 19, May, 1942, pp. 70, 108.

29 "Process Anneals of Alloy Mold Steels," by E. K. Spring and J. K. Desmond, *Modern Plastics*, vol. 19, Mar., 1942, pp. 61–63, 96.

APPLICATIONS

30 "Ordnance Developments," by E. T. McBride, *Modern Plastics*, vol. 19, Apr., 1942, pp. 39–41.

31 "Artillery Ammunition—A Challenge," by F. A. Marshall, *Modern Plastics*, vol. 19, June, 1942, pp. 46–47, 104, 106, and 108.

32 "Molded Ammunition Rollers," by Carl Marquardt, *Modern Plastics*, vol. 19, Aug., 1942, pp. 40–41, 124, 126, 128, and 130.

33 "The Army's Auxiliary Booster Tube," *Modern Plastics*, vol. 20, Oct., 1942, pp. 65–66, 142.

34 "The Army Helmet Liner," *Modern Plastics*, vol. 19, May, 1942, pp. 35–38, 104, 106, and 108.

35 "Triumph in a Helmet," *Modern Plastics*, vol. 20, Nov., 1942, pp. 53–55.

36 "Molding the Thunderer," *Modern Plastics*, vol. 20, Sept 1942, pp. 43, 120.

37 "Taps for Brass," *Modern Plastics*, vol. 20, Nov., 1942, pp. 63, 134, 136.

38 "Working Skis for U. S. Troops," *Modern Plastics*, vol. 19, May, 1942, pp. 50–51, 108.

39 "Right for Rain," *Modern Plastics*, vol. 19, July, 1942, pp. 40–43, 110.

40 "New Materials Meet an Old Threat," *Modern Plastics*, vol. 19, June, 1942, pp. 35–43, 108, 110, 112, 114, 116, 118, and 120.

41 "Converting for Uncle Sam," by E. F. Lougee, *Modern Plastics*, vol. 19, July, 1942, pp. 58–59, 120.

42 "Plotting the Course," *Modern Plastics*, vol. 19, May, 1942, p. 39.

43 "Navy Applications," by J. B. Lunsford, *Modern Plastics*, vol. 19, Apr., 1942, pp. 41–44.

44 "Insulation Aboard U. S. Navy Vessels," by J. B. Lunsford, *Modern Plastics*, vol. 20, Oct., 1942, pp. 45–49, 126, and 128.

45 "Covering Binocular Bodies," by W. R. Bailey, *Modern Plastics*, vol. 20, Oct., 1942, pp. 50–53.

46 "Reducing Breakage in the Navy," *Modern Plastics*, vol. 20, Nov., 1942, pp. 80–81, 122.

47 "The Little Boats," *Modern Plastics*, vol. 19, Mar., 1942, pp. 35–37, 102, 104.

48 "Boats for the Army," *Modern Plastics*, vol. 19, Aug., 1942, pp. 45, 108.

49 "Night Vision Goggles," *Modern Plastics*, vol. 19, June, 1942, p. 55.

50 "Wired Window Protection," *Modern Plastics*, vol. 19, July, 1942, pp. 52, 108.

51 "Parachute Flare Base," *Modern Plastics*, vol. 19, Aug., 1942, pp. 57, 120.

52 "The People's Pump," *Modern Plastics*, vol. 19, July, 1942, pp. 38–39, 118, 120.

53 "The 'Baltimore' Mast," *Modern Plastics*, vol. 19, Mar., 1942, pp. 39–41, 100, 102.

54 "Tooling for Aircraft Production," *Modern Plastics*, vol. 19, July, 1942, pp. 33–37, 104, 106, and 108.

55 "Fairlead Guide Blocks," *Modern Plastics*, vol. 19, July, 1942, pp. 62–63, 112.

56 "Canvas Pilot Seat," *Aviation Equipment*, vol. 2, May, 1942, p. 12.

57 "Airplane Pilot Seats," *Modern Plastics*, vol. 19, Aug., 1942, pp. 48–49, 118.

58 "Tokyo and Return," by H. M. Richardson, *Modern Plastics*, vol. 19, Aug., 1942, pp. 42–43, 134, 136.

59 "Jablo Airscrew Blades," *Aircraft Production*, vol. 4, April, 1942, pp. 277–282.

60 "Victory Trainer," *Modern Plastics*, vol. 19, Jan., 1942, pp. 42–43.

61 "Steel-Plywood Trainer," *Modern Plastics*, vol. 19, June, 1942, pp. 45, 98, 100.

62 "Troop-Carrying Glider," *Aero Digest*, vol. 40, Jan., 1942, p. 299.

63 "Hot Wings and Cold-Set Resins," *Modern Plastics*, vol. 20, Sept., 1942, pp. 52–55.

64 "Wood-Plastic Airplane Parts," by C. L. Bates, *Aviation*, vol. 41, Jan., 1942, pp. 82–83, 182.

65 "Resin-Bonded Wood Laminates for Shell-Type Aircraft Structures," by A. A. Gassner, *Journal of the Aeronautical Sciences*, vol. 9, Mar., 1942, pp. 161–171.

66 "Synthetic Resins in Construction," by H. N. Haut, *Aviation*, vol. 41, Mar., 1942, pp. 84–85; also Apr., 1942, pp. 103, 105, 210, 213, 214.

67 "The Uses of Plywood in Aircraft," by T. D. Perry, *Aero Digest*, vol. 41, July, 1942, pp. 200, 205–206.

68 "Use of Plastics and Allied Materials in Aircraft Construction," by G. W. DeBell, *Journal of the Aeronautical Sciences*, vol. 9, July, 1942, pp. 341–349.

69 "Glued-Laminated Wood Construction," *Modern Plastics*, vol. 19, Feb., 1942, pp. 44–45.

70 "High-Density Plywood," by T. D. Perry, *Modern Plastics*, vol. 19, May, 1942, pp. 61–63, 110, 112, 114.

71 "Scarfed Joints in Plywood," by T. D. Perry, *Modern Plastics*, vol. 20, Sept., 1942, pp. 74–75, 116, 118, 120.

72 "Impregnated Plywood Becomes War Material," by J. DelMonte, *Machine Design*, vol. 14, July, 1942, pp. 53–57.

73 "Adhesives Industry Is Modernized," by M. H. Bigelow, *Chemical and Metallurgical Engineering*, vol. 49, Feb., 1942, pp. 121–124.

74 "Chemical Factors Involved in the Gluing of Wood With Cold-Setting Urea-Formaldehyde Resins," by W. G. Campbell, *Chemistry and Industry*, vol. 61, Apr. 4, 1942, pp. 161–162.

75 "The Use of Glue in Wooden Aircraft," by J. G. McDermot, *Aero Digest*, vol. 41, July, 1942, pp. 186, 267–270.

76 "Marine Bearings," by H. C. Irvin, *Modern Plastics*, vol. 19, Apr., 1942, pp. 33–34, 120.

77 "Plastics for Water-Meter Disks," by J. D. Piper, *Modern Plastics*, vol. 19, Apr., 1942, pp. 68–71.

78 "Signs for the Duration—and After," *Modern Plastics*, vol. 19, June, 1942, pp. 51–54.

79 "Closures and the Bottleneck," *Modern Packaging*, vol. 16, Sept., 1942, pp. 37–52.

80 "Eclipse of Tin and Aluminum," *Plastics*, vol. 5, Jan., 1942, p. 248.

81 "Extruded Collapsible Tube, *Modern Plastics*, vol. 20, Nov., 1942, pp. 58–59.

82 "Printing With Thermoplastic Plates," by E. A. Williamson, *Modern Plastics*, vol. 20, Oct., 1942, pp. 59–61.

83 "Urea Plastics in Lighting Fixtures," by R. B. Barnes and C. R. Stock, *Modern Plastics*, vol. 19, Feb., 1942, pp. 61–65, 96, 98, 100.

84 "Acrylic Resins for Dentures," by W. T. Sweeney, G. C. Paffenbarger, and J. R. Beall, *Modern Plastics*, vol. 19, Apr., 1942, pp. 61–67, 104, 106, 108, 110, 112, and 114.

85 "Soft, Rubberlike Plastics," by D. R. Wiggam, *Modern Plastics*, vol. 19, Aug., 1942, pp. 50–51.

86 "Synthetic Resin Replaces Rubber," *Modern Plastics*, vol. 19, Aug., 1942, pp. 66–67, 132, 134.

87 "Plastics That Can Help the Shipbuilding Industry," *Plastics*, vol. 6, Mar., 1942, pp. 52–59.

88 "Plastic Building Components," by G. Fejer, *Plastics*, vol. 6, Apr., 1942, pp. 90–97.

89 "The Use of Plastics in Building," by R. J. Schaffer, *Chemistry and Industry*, vol. 61, Aug. 22, 1942, pp. 357–361.

90 "Planning Postwar Applications," by Carl Sundberg and Montgomery Ferar, *Modern Plastics*, vol. 19, Aug., 1942, pp. 52–53, 116, 118.

91 "Effect of War Development on Post-War Car Design," by F. Jardine, *S.A.E. Journal*, Trans. Section, vol. 50, July, 1942, pp. 299–303.

92 "The Future of the Plastics Industry," by R. P. Chew, *Chemical Industries*, vol. 51, Aug., 1942, pp. 214–219.

93 "Automobile Body Construction," by Henry Ford, U. S. Patent 2,269,451, Jan. 13, 1942.

PROPERTIES, TESTING, AND SPECIFICATIONS

94 "Temperature Vs. Strength for Phenolics," by T. S. Carswell,

(*Continued on page 260*)

ADVANCES *in* RUBBER *During* 1942

By J. H. DILLON

PHYSICAL RESEARCH DIVISION, THE FIRESTONE TIRE AND RUBBER CO., AKRON, OHIO

PEARL HARBOR and subsequent events in the Far East made 1942 a year of amazing and far-reaching changes in the field of resilient materials. With the United Nations suddenly cut off from over 90 per cent of their crude-rubber sources, it became necessary to develop immediately and produce adequate quantities of rubber substitutes. In general, the principal emphasis in the field of synthetic rubber prior to the war emergency had been to develop "specialty rubbers," designed to give better performance in certain particular types of service where resistance to oil, solvents, ozone, etc., was essential. Substantial progress in the development of general-purpose substitute rubbers had been made, but large-scale experience in their production and application was lacking as 1942 began. Fortunately, a moderate supply of crude rubber existed in the United States and this, combined with a large production of reclaimed rubber, has served to meet essential military requirements as the great new Buna-S[1] plants come into production and experience is gained with Buna-S products of all types. Meanwhile the limited production of Neoprene, Thiokol, Butyl, and the several varieties of acrylonitrile-butadiene rubbers are being used to capacity in specialized military applications.

It is clear, then, that the mechanical engineer no longer has at his disposal unlimited quantities of resilient materials of time-tested quality. His first responsibility in 1942 was to reduce or, if possible, eliminate rubber or synthetic rubber in existing machines and other products and employ it as little as possible in new designs. It was necessary for him to be thoroughly conversant with the availability and properties of the various types of rubbers, natural and synthetic, so that he might be able to select the type best suited to a given application without unnecessary depletion of the limited supply of the higher-quality rubbers.

AVAILABILITY OF NATURAL AND SYNTHETIC RUBBERS

An excellent summary on the present supply and projected production of natural and synthetic rubbers is given in the complete Baruch Report (1).[2] An accurate description of progress in synthetic rubber is given by H. I. Cramer (2). Necessary wartime secrecy has severely limited publication of detailed data on military products employing rubber and synthetics. Nevertheless, because of the magnitude of the development program, considerable literature has accumulated in 1942. Reclaimed rubber (3, 4) found increasing use in combination with both natural rubber and Buna-S. Passenger-tire recaps made entirely with reclaim have given reasonably good tire mileages. An improved type of reclaim has been announced by the Boston Woven Hose Company, but details concerning its manufacture and properties have not been publicly announced (5).

While small but important shipments of Hevea rubber should continue to arrive from Africa and from South and Central America in increasing amounts, intensive efforts have been made to develop other natural-rubber-yielding plants which can be grown in North America. Of these, the Guayule shrub is the most promising and, as projected plantings give greater and greater yields, Guayule rubber in its deresinated form will be of great value as a partial replacement for Hevea rubber. Passenger-car tires and tubes made exclusively of underesinated Guayule were reported to give mileages of 8500 to 10,500 as early as 1934 (6). More recent data on the properties of Guayule have appeared (7, 8). Other types of rubber-yielding plants which are being studied include Cryptostegia grandiflora, Fosteronia floribunda, Asclepias sublata (milkweed), and goldenrod. X-ray diffraction diagrams which show the similarity of these rubbers to Hevea have been published (9).

BUNA-S SELECTED FOR MASS PRODUCTION

Buna-S, a copolymer of butadiene and styrene, has been chosen as the principal mass-production synthetic rubber on the basis of its general characteristics and relative facility for economical production from domestic raw materials, petroleum, or alcohol and coal tar. Like all known synthetic rubbers, it has a rather high internal friction and, hence, generates more heat in dynamic applications than does natural rubber (10). It is weak and easily torn in a gum stock, but, when loaded with adequate concentrations of carbon black, shows good tensile and abrasive properties (11, 12, 13). It appears to resist decomposition at high temperatures better than does natural rubber (14). It resists oils, solvents, and ozone to about the same extent as natural rubber and is not outstanding in these respects. Although more difficult to process than natural rubber, with certain changes in techniques, it can be handled with regular rubber-processing equipment (15). Difficulties are encountered in adhering it to itself because of its characteristic lack of tack in the unvulcanized state, but these are being overcome (16).

Passenger tires constructed entirely with Buna-S compounds have proved fully equal to tires made with Hevea rubber. Truck and bus-size tires have presented a greater problem, but rapid developments of the past few months indicate that this problem is being solved also. This same statement applies to nearly all mechanical-goods applications.

Unquestionably, the development of processing methods and compounds of Buna-S, in 1942, constitutes the greatest progress in the rubber industry in many years. Much remains to be learned in the application of Buna-S, and the mechanical engineer will play an important part in this program.

SPECIAL APPLICATIONS FOR WHICH NEOPRENE IS ADAPTED

Neoprene in its various forms can hardly be termed a development of 1942, for engineers had become familiar with its high resistance to oils and ozone (17) and had found many applications for it. Because of its oil and solvent resistance, it has been employed in self-sealing fuel tanks and hose. Because of its low permeability to gases and high ozone resistance, it has

[1] Note that the Buna-S made in the United States is similar, but not identical, to the German Buna-S.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Rubber and Plastics Group of the Process Industries Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

been used almost exclusively for coating the fabric of barrage balloons which now operate at altitudes of 10,000 to 15,000 ft. The low resistance of Neoprene to cold, as compared to Hevea rubber and Buna-S, has become a serious difficulty in its application to high-altitude-airplane parts (18). However, a new variety, Neoprene FR, has been brought out which has a much improved flexibility at low temperatures (19). Neoprene cements have been of great value for adhering not only Neoprene but natural rubber and other synthetics. Neoprene latex appears to show promise in many applications.

MANY SYNTHETIC RUBBERS AVAILABLE IN LIMITED QUANTITIES

The acrylonitrile-butadiene copolymer-type synthetics (Perbunan, Hycar OR, Chemigum I, II, and III, Butaprene-N types, etc.) have not been manufactured in large volume because of the necessity of employing most of the available butadiene in Buna-S, and the acute shortage of acrylonitrile. The limited amounts available, however, have been used very effectively in self-sealing fuel and oil tanks, bulletproof hose, etc., where their exceptional resistance to ordinary gasoline and oil are of value (20, 21). They are not entirely proof against aromatic fuels and lose flexibility at low temperatures. Butaprene NF, a material of this type having improved resistance to cold, has been announced (22).

Materials of this type are not comparable to Neoprene and Butyl in resistance to ozone. Like Buna-S, they require a rather high carbon-black loading in order to develop good physical properties, have a higher internal friction, and are more difficult to process and adhere. In general, a rather high percentage of a softener (10 per cent or more) is employed to make processing possible. Such softeners thus act as extenders for the material and in some cases improve its low-temperature flexibility.

Butyl rubber, reported to be a copolymer of isobutylene with butadiene or isoprene, has become available in small quantities for certain special military uses (23, 24). It possesses a very low chemical unsaturation, and hence is very stable chemically. It has a very low permeability to gases and at the same time has a lower specific gravity than Neoprene, 0.9175 as compared to 1.25 (25). Hence it has excellent possibilities as a proofing material for balloon fabrics. It has been tested in passenger-size tires and in recaps but does not appear to have the abrasion resistance possessed by Hevea rubber. It has been stated that it is adaptable to fire hose, steam hose, molded goods, and conveyer belts. A more easily produced lower-quality variety of Butyl called Flexon has also been tested as an emergency recap material for passenger tires with some success.

The several varieties of Thiokol, organic polysulphides, have been in use for a number of years in products where oil resistance, ozone resistance, or low gas permeability is essential (26). Thiokol has an extremely unpleasant odor and is thermoplastic; hence it is very limited in application. However, recent tests with Thiokol recaps have indicated it as a possible emergency material, providing its extremely poor cold resistance is corrected. A new odorless variety, Thiokol RD, has lately been announced which is reported not to be a polysulphide reaction product (27).

A group of materials which can be used to replace rubber in gaskets, hose, coatings, etc., but which are thermoplastic and not highly extensible, has become increasingly important (2). This group includes Koroseal, Vinylite, Resistoflex (28), Velon, Saran, Formvar, Butvar, Butacite, Acryloid, plasticized ethyl cellulose, and plasticized cellulose acetate (29). Most of these materials are tough and flexible and have high resistance to oils and solvents. Some of them have been tested in tire recaps with small success to date.

Incidentally, all materials of low extensibility, such as wood, vulcanized fiber, etc., have proved entirely unsuitable for automobile tires, in the opinion of competent engineers, although many optimistic statements have appeared in the public press. A new product called Norepol, produced from soybean oil, appears to approximate rubber to a higher degree (30, 31). It has shown promise as a tire-recap material.

SYNTHETIC-RUBBER HEAVY-DUTY TIRE A 1942 ACHIEVEMENT

The greatest product development of 1942 was undoubtedly that of the synthetic-rubber heavy-duty tire. Details are completely lacking in the literature and none can be revealed here. Some basic design data on tires have been given, however (32, 33).

An interesting paper on rubber tracks for military vehicles and tractors has been published (34). Intensive work has been done on bulletproof combat tires and tubes for various types of military vehicles. The replacement of rubber in tank-track blocks by steel has eliminated a difficult problem for the rubber technologist and results in a large rubber saving. However, it is doubtful if this step will make the perfection of the bogie roller less difficult. It certainly has not eliminated tank radio static. The introduction of electrically conducting rubber in the track-block bushings should be effective in this respect. A paper which treats the problem of static electricity in pneumatic tires and its solution by means of electrically conducting treads and sidewalls has been published (35). Conducting rubber compounds have been employed to an increasing extent in 1942, in airplane tires, industrial tires for munitions plants, flooring and caster wheels for hospital operating rooms, truck and bus tires, etc.

SELF-SEALING AIRPLANE FUEL TANKS AN OUTSTANDING DEVELOPMENT

Very little detailed information has been given on the many new types of rubber parts for aircraft and military vehicles. Two very valuable papers on the vibrational properties of rubber have appeared (36, 37). Outstanding among aircraft developments are self-sealing fuel and oil tanks. Their use has already permitted the return of many a bullet-riddled bomber or fighter to its base and saved the lives of many pilots. In general, these tanks have been of the internal type. The 1942 designs have been improved in sealing qualities against heavy-caliber ammunition, effectiveness at low temperatures, and resistance to penetration of fuel through the inner liner. Weight and wall thicknesses have been reduced. The danger of extraction of soluble materials from the inner liner has been greatly decreased, and the problems introduced by the use of aromatic fuels are approaching solution. It now appears that fuel tanks must be made "crashproof" as well as self-sealing. Self-sealing hose for fuel and oil lines has been vastly improved in 1942 also.

Intensive development work has resulted in a wide variety of inflatable products classed as flotation gear. This class includes life belts, life rafts, landing boats, and pontoons capable of supporting a bridge for 30-ton tanks. Several varieties of barrage balloons for both naval and land service have been engineered and put into large-scale production during the past year.

In the field of industrial products, conveyer and transmission belts, reinforced with steel cable cords, have been notable contributions to war production. A new development in airplane-tire design is the "channel tread" which is reported to give improved traction, flotation, and load-carrying capacity. It is particularly effective in tail-wheel tires for catapult planes.

An airplane tire with metal studs cured into the tread for use on ice-covered landing strips has been announced. Another type has a tread made of soft crepe rubber. An extremely interesting item, from the standpoint of the future, is a soundproof room supported on rubber, developed at Northwestern University.

CLASSIFICATION OF RUBBER AND SYNTHETICS

Work on the A.S.T.M. Hardness Test project has been inter-

rupted by the exigencies of the war effort. Tentative recommendations have been made, however (38). A laudable beginning has been made by a joint A.S.T.M.-S.A.E. committee in the classification of rubber and synthetic-rubber stocks according to their physical properties (39).

The technical literature includes many valuable papers on the properties and testing of natural and synthetic-rubber stocks (40 to 47). An enormous amount of theoretical work on the structure of rubberlike materials has been reported in the literature of the past year (48 to 53). Only a few of these papers can be included in this bibliography, but it may be said that great progress has been made in this field which will eventually lead to results with practical engineering value. In general, progress in rubber technology and engineering in 1942 has been of the highest order. When the necessity of wartime secrecy finally disappears, 1942 may prove to have been the outstanding year in the history of rubber progress.

BIBLIOGRAPHY

1 Report of the Rubber Survey Committee, Sept. 10, 1942, by James B. Conant, Karl T. Compton, and Bernard M. Baruch.

2 "Industrial Progress in Synthetic Rubberlike Polymers," by H. I. Cramer, *Industrial and Engineering Chemistry*, vol. 34, Feb., 1942, pp. 243–251.

3 "General Principles of Compounding With Reclaim," by P. M. Elliot, *Rubber Age*, vol. 51, April, 1942, pp. 35–36.

4 "Natural Aging of Reclaimed Rubber," by H. F. Palmer and R. H. Crossley, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1367–1370.

5 "Boston Woven Hose Reclaim Process," *India Rubber World*, vol. 107, Nov., 1942, pp. 186–187.

6 "Guayule Rubber in Tires and Tubes," by J. H. Doering, *Industrial and Engineering Chemistry*, vol. 26, May, 1934, pp. 541–543.

7 "The Compounding of Guayule Rubbers," by R. E. Morris, R. R. James, T. A. Werkenthin, *India Rubber World*, vol. 105, March, 1942, pp. 565–569; also *India Rubber World*, vol. 107, Oct., 1942, pp. 31–32.

8 "Guayule Rubbers in Wire and Cable Insulation," by R. E. Morris, F. J. Gorman, T. A. Werkenthin, and J. B. Lunsford, *Rubber Age*, New York, N. Y., vol. 51, Sept., 1942, pp. 479–481.

9 "Domestic Rubber Plant Investigation Launched by U. S. Rubber Co.," *Rubber Age*, New York, N. Y., vol. 51, June, 1942, pp. 213–214.

10 "Vibration Properties of Rubberlike Materials," by R. B. Stambaugh, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1358–1365.

11 "Study of Carbon Blacks in Natural and Synthetic Rubbers," by I. Drogim, *India Rubber World*, vol. 106, part I, Sept., 1942, pp. 561–569; also *India Rubber World*, vol. 107, part II, Oct., 1942, pp. 42–49.

12 "The Compounding and Processing of Government Synthetic Rubber," by C. A. Carlton and E. B. Reinbold, *Rubber Age*, New York, N. Y., vol. 52, Oct., 1942, pp. 29–34.

13 "Effect of Carbon Blacks in Synthetic Tire Compounds," by B. S. Garvey, Jr., and J. A. Freese, Jr., *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1277–1283.

14 "Thermal Decomposition of Natural and Synthetic Rubber Stocks," by I. B. Prettyman, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1294–1298.

15 "Processing Characteristics of Synthetic Tire Rubber," by B. S. Garvey, Jr., M. H. Whitlock, and J. A. Freese, Jr., *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1309–1312.

16 "Stickiness, Tackiness, and Spinnability," by D. Josefowitz and H. Mark, *India Rubber World*, vol. 106, April, 1942, pp. 33–37.

17 "Effect of Petroleum Products on Neoprene Vulcanizates," by D. F. Fraser, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1298–1300.

18 "Brittle Point of Rubber Upon Freezing," by M. L. Selker, G. G. Winspear, and A. R. Kemp, *Industrial and Engineering Chemistry*, vol. 34, Feb., 1942, pp. 157–160.

19 "Effect of Low Temperatures on Neoprene Vulcanizates," by F. L. Yerzley and D. F. Fraser, *Industrial and Engineering Chemistry*, vol. 34, March, 1942, pp. 332–336.

20 "Perbunan Properties and Compounding," by R. A. Moll, R. M. Howlett, and D. J. Buckley, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1284–1291.

21 "Volume Change of Hycar OR-15 Compounds on Immersion," by A. E. Juve and B. S. Garvey, Jr., *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1316–1319.

22 "How Synthetic Rubbers Meet Current Demand," by O. D. Cole, *Machine Design*, vol. 14, July, 1942, pp. 76–81.

23 "Butyl Rubber Properties and Compounding," by J. P. Haworth and F. B. Baldwin, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1301–1308.

24 "The Compounding and Processing of Butyl Rubber," by I. E. Lightbown, *Rubber Age*, New York, N. Y., vol. 51, Aug., 1942, pp. 377–380.

25 "Density Measurements on Synthetic Rubbers," by L. A. Wood, N. Bekkedahl, and F. L. Roth, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1291–1293.

26 "Thiokol," by W. A. Stevens, Trans., Institution of the Rubber Industry, vol. 18, 1942, pp. 17–31.

27 "Thiokol, Synthetic Rubber Type RD," by J. W. Crosby, *India Rubber World*, vol. 106, May, 1942, pp. 133–135.

28 "Properties and Uses of Resistoflex PVA—A Rubberlike Compound," by H. E. Krebs, *Rubber Age*, New York, N. Y., vol. 51, July, 1942, pp. 299–301.

29 "Soft Rubberlike Plastics From Cellulose Derivatives," by D. R. Wiggam, *Rubber Age*, New York, N. Y., vol. 51, Aug., 1942, pp. 381–382.

30 "Interim Tires and Retreads (Pamphlet prepared by Automotive and Rubber Industry Tire Committee), vol. 6, Nov. 3, 1942, Sect. 1, p. 1.

31 "Rubberlike Material From Soybean and Corn Oils," the *Chemurgic Digest*, vol. 1, Aug. 31, 1942, p. 121.

32 "Rolling Resistance of Pneumatic Tires as a Factor in Car Economy," by W. F. Billingsley, R. D. Evans, W. H. Hulswit, and E. A. Roberts, *S.A.E. Journal*, vol. 50, Feb., 1942, pp. 37–39 and 72.

33 "Selection of Earth-Moving Tires for Better Performance and Economy," by W. Lee, *S.A.E. Journal*, vol. 50, March, 1942, pp. 73–79.

34 "The 'Square-Wheel' Tractor Goes to Town," by R. Mayne and H. W. Delzell, *S.A.E. Journal*, vol. 50, March, 1942, pp. 97–101.

35 "Static Electric Problems in Tires," by J. W. Liska and E. E. Hanson, *Industrial and Engineering Chemistry*, vol. 34, May, 1942, pp. 618–624.

36 "Vibration and Rubber Springs," by W. C. Keys, MECHANICAL ENGINEERING, vol. 64, March, 1942, pp. 175–180.

37 "Rubber in Vibration," by S. D. Gehman, *Journal of Applied Physics*, vol. 13, June, 1942, pp. 402–413.

38 "Report of Hardness Test Section of Technical Committee A on Automotive Rubber, Committee D-11," by L. V. Cooper, A.S.T.M. Bulletin, No. 115, March, 1942, pp. 37–38.

39 "S.A.E.-A.S.T.M. Classifications and Tests Recommended for Natural Rubber and Synthetic Rubber Compounds," A.S.T.M. Bulletin, No. 117, Aug., 1942, pp. 66–69.

40 "Evaluation of Small Amounts of Synthetic Rubber," by B. S. Garvey, Jr., *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1320–1323.

41 "Tensile Testing of Rubber Compounds at High Temperatures," by R. Thorndike, *Rubber Age*, New York, N. Y., vol. 50, Feb., 1942, pp. 345–352.

42 "The Effect of Temperature on the Sunlight Deterioration of a Rubber Compound," by J. M. Ball and C. E. Bradley, Jr., *Rubber Age*, New York, N. Y., vol. 50, March, 1942, pp. 425–430.

43 "Effect of Temperature and Pressure on Oxygen Pressure Aging," by A. M. Neal, H. G. Bimmerman, and J. R. Vincent, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1352–1357.

44 "Sunlight and Accelerated Light Aging of Synthetic Rubbers," by R. E. Morris, R. R. James, and T. A. Werkenthin, *Rubber Age*, New York, N. Y., vol. 51, June, 1942, pp. 205–208.

45 "Rise of Temperature on Fast Stretching of Synthetics and Natural Rubbers," by S. L. Dart, R. L. Anthony, and E. Guth, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1340–1342.

46 "Frictional Properties of Rubber," by F. L. Roth, R. L. Driscoll, and W. L. Holt, U. S. Bureau of Standards, *Journal of Research*, vol. 28, April, 1942, pp. 439–462.

47 "Equation of State of Some Synthetic Rubbers," by L. E. Peterson, R. L. Anthony, and E. Guth, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1349–1352.

48 "The Kinetics of High Elasticity in Synthetic Polymers," by R. F. Tuckett, *Rubber Chemistry and Technology*, vol. 15, July, 1942, pp. 430–445.

49 "The Micellar Theory of the Structure of Rubber," by G. Gee, Trans. Faraday Society, vol. 38, Feb.-March, 1942, pp. 109–115.

50 "Phase Transition and Elastic Behavior of High Polymers," by H. Mark, *Industrial and Engineering Chemistry*, vol. 34, April, 1942, pp. 449–454.

51 "A Statistical Treatment of Crystallization Phenomena in High Polymers," by T. Alfrey and H. Mark, *Journal of Physical Chemistry*, vol. 46, Jan., 1942, pp. 112–118.

52 "Statistical Thermodynamics of Rubber," by F. T. Wall, *Journal of Chemical Physics*, vol. 10, Feb., 1942, pp. 132–134.

53 "Intermolecular Forces and Mechanical Behavior of High Polymers," by H. Mark, *Industrial and Engineering Chemistry*, vol. 34, Nov., 1942, pp. 1343–1348.

The AMERICAN ENGINEER *and the* WAR EFFORT

By A. A. POTTER

DEAN OF ENGINEERING, PURDUE UNIVERSITY

I ACCEPT this plaque with deep gratitude but feel most humble when I compare my own attainments and contributions with those of the other recipients of the Washington Award. You and my other friends in the engineering profession and on the faculties of our engineering colleges have given me an honor far greater than I deserve. For everything I have achieved I am indebted to this country of my adoption, the true land of opportunity, which has offered me during the past forty-five years every encouragement and incentive. My only hope is that we may be able to preserve this country, so that others in the future may also enjoy its privileges and benefit by American idealism.

On Oct. 14, 1941, two months before the deceitful and treacherous Japanese attack on Pearl Harbor, I had the pleasure of discussing with many of you, at the Fall Dinner Meeting of the Western Society of Engineers, the plans for building up our defense to safeguard the nation. That defense program, which involved an expenditure of about sixty billion dollars, has been increased to a wartime program which will cost more than 200 billion dollars by the end of the present calendar year.

The past fifteen months have witnessed many changes which are greatly challenging the ingenuity of our profession. Our former abundance of manpower and raw materials now seems like a mirage, as acute shortages have developed which are seriously affecting not only industry but also civilian needs. Engineers and scientists are endeavoring to meet both the scarcity of manpower and the scarcity of materials. They are inaugurating specialized training programs, methods of upgrading, more efficient management, and greater mechanization to meet the problems resulting from labor shortage. They are developing new substitute products to relieve the strain on scarce materials. Furthermore, through better utilization of plant capacity and transportation facilities, they are greatly increasing the quantity of essential materials available for war production. It is to the lasting credit of engineers that the steel industry has been able to double its output since 1939 with only slightly increased capacity. It should prove most gratifying to our colleagues in the transportation field that our railroads are carrying about two and one half times the freight carried in 1918, with less rolling stock. The enormous demands for electric power in connection with war production are being met by a better integration of existing facilities, greater use of reserve capacity, and a greatly increased use factor. The story of the conversion of our automotive industry to meet war needs, when fully told, will reflect enormous credit upon those skilled in the engineering and production techniques. The growth in quantity of output and improvement in quality which have been achieved by the airplane and shipbuilding industries during the past 30 months is another manifestation of the engineering talent in our land.

The public at large is beginning to realize that American engineers can do most with least in the shortest possible time. Never before, in war or peace, have the members of our profession commanded such public respect and exerted such outstanding influence as they do today.

An address delivered in accepting the Washington Award at Chicago, Ill., Feb. 24, 1943.

GREATEST SHORTAGE IS IN SPECIALIZED SKILLS

These American engineers and scientists, however, are too few to carry the great task entrusted to them. Although we speak more often about the scarcity of tin, copper, and steel, the fact remains that our greatest shortage is not in materials but in men and women with specialized skills, particularly engineers and scientists, who cannot be trained in a few days or even in a few weeks. The output of engineering colleges, which was barely sufficient to meet the needs of industry during normal times, is falling very short of satisfying the most critical needs of our armed forces and of our war industries. The War Training Program in Engineering, Science, and Management under the auspices of the U. S. Office of Education, through intensive in-service and pre-service courses on the college level, has been most helpful in supplementing the output of engineering colleges by training men and women for industry as assistants to engineers, technicians, inspectors, draftsmen, production supervisors, and commissioned-officer specialists for the armed forces. Under this program over 660,000 people were trained or retrained from Oct. 9, 1940, to June 30, 1942, and it is expected that by the end of the present fiscal year, June 30, 1943, the number of persons who have received such training since Oct. 9, 1940, will exceed one and one quarter million.

While the War Training Program in Engineering, Science, and Management, under the auspices of the U. S. Office of Education, is meeting a critical need for specialized personnel, the shortage of fully trained engineers for service to war industry and in the armed forces is becoming more acute. The majority of our engineering colleges are attempting to alleviate this situation by operating on a continuous year-round or expedited plan, which will make available about a fourth more engineering graduates during the year ending June, 1943. This plan, by reducing vacations to a minimum, makes it possible for a high-school graduate to complete the requirements for a bachelor's degree in engineering in two and two thirds or three years, in place of four years, and without any appreciable lowering of standards.

There is little dependable information concerning the use which the armed forces will make of our engineering colleges. One thing is certain—our educational institutions of higher learning "will not be taken over by the Government." The Army is planning to send, between March 1 and July 1, 1943, to higher educational institutions, mainly engineering and medical schools, about 150,000 young people in uniform, after these inducted soldiers have completed a 13-week indoctrination training period. The Navy expects to send to engineering colleges about 75,000 people between May 1, 1943, and January 1, 1944. These students in uniform will pursue prescribed programs on the engineering-college level, which will require about 60 clock hours per week in class and preparation. It is expected that the prescribed program will differ only slightly from the approved normal curricula of engineering colleges but will be shorter, more specific, and will devote little time to humanities and social sciences. It is expected that the product from the prescribed curricula will not be as well prepared as are our present engineering graduates, although the soldiers sent

to colleges will have been carefully selected through certain screening tests and will have no financial worries, because the Government will pay their tuition and subsistence in addition to a private's pay of $50 per month.

INDUSTRY NEEDS ENGINEERING GRADUATES

While the foregoing plan will make available a large number of fairly well prepared engineers for the armed forces, the need for engineers on the part of war industries is bound to become more and more critical. The engineering colleges will, no doubt, be used to capacity for special instruction of value to the armed forces, but unless the war industries make their wants known to our Government, the supply of engineers for industry will be very greatly curtailed. Our war industries will continue to need a steady replacement supply of engineers for the planning, design, and mass production of armaments and other munitions of war. The engineering colleges of our country must continue to be the major sources of this supply. Several of our leading engineering societies have endeavored, through resolutions to the President of the United States, to impress upon our Government that the effective prosecution of modern mechanized warfare demands that an adequate supply of engineers is insured for war industries as well as for the armed forces. While Selective Service has been fairly liberal in deferring engineering students who have completed about one year's work in an accredited professional engineering curriculum, the needs of war industry will not be satisfied until an industry reserve is set up so that young people can prepare for service to war industry under conditions which are not materially different from those planned by the Army and Navy. It is felt that few engineering students will apply for deferment when the majority of the men students enrolled in engineering colleges are in uniform. Our Government must be fully advised about the needs of our war industries for engineers who have the ability to plan, design, improve, and supervise mass production of equipment and scientific devices needed by our armed forces. United action on the part of our profession and particularly by engineers connected with war industries is essential in order to insure an adequate and continuous supply of well-educated and thoroughly qualified engineers for service to the war industries as well as in the armed forces of our land. It is also important that those in authority in our Government are fully impressed with the fact that in modern mechanized warfare there is as much need for commissioned officers with superior engineering knowledge as there is for commissioned officers with strategic and tactical skill and that such engineering knowledge cannot be imparted through short courses of a few weeks. Production of high-grade engineering talent does not take place quickly or automatically, any more than does the production of highly complicated armaments. The fully prepared and well-educated engineering-college graduate is needed in large numbers both for war industries and for the armed forces.

AMERICAN PATENT SYSTEM HAS RAISED OUR LIVING STANDARDS

Totalitarian states have sought "abundant life" by exploiting the assets of all for the benefit of their unscrupulous groups and have resorted to banditry, racketeering, and trickery to attain their objectives. In contrast with this, our creative people, stimulated by our patent system and aided by a foresighted Government that has always encouraged individual enterprise, have converted this country, in the short period of 153 years, from a small, struggling nation into the most powerful industrial people in the entire world. During the same period, the standard of living of our people has raised from bare subsistence to a point where we enjoy the highest living standards known in history, If we wish our nation to advance in the future as it has in the past, we must preserve free enterprise, maintain high standards of education, and safeguard our patent system.

It is significant that most of the epoch-making inventions of the past 150 years are the product of American genius. War incentives have stimulated invention and developments which are resulting in new devices of great value to our armed forces. While some of these creative achievements of the past two years must remain military secrets for a long time in the interest of national defense, many others should prove most valuable during the postwar period in developing new opportunities for employment and in raising the standards of living of people the world over. If maximum use is to be made of our inventive talent to insure victory in our present struggle and to meet adequately the challenge which will be ours during the postwar period, we must make certain that we have a sound patent system which protects the inventor and investor alike. Few realize that there is a difference between an invention and a marketable product. An invention, to be commercialized, usually requires considerable expenditure for research and development. To benefit the public through new and useful inventions, not only the invention but its development requires the assurance of protection. Our patent system, which was created by an Act of Congress, signed by President George Washington on April 10, 1790, has provided an incentive to the inventor and to capital for the encouragement of research and development needed to commercialize an invention. Under our patent system the production and utilization of new ideas have taken place at a very rapid rate, and in amount which has outstripped all other lands.

Like all institutions created by human beings, our patent system is not perfect, but it has demonstrated its merit and has served as the model for the patent systems of all industrial nations. Six different groups have appraised our patent system during the past 30 years. These include the President's Commission on Economy and Efficiency (1912), the Patent Committee of the National Research Council (1919), the Committee on Patent Office Procedure of the Department of Commerce (1926), the Science Advisory Board (1935), the Joint Patent Inquiry of the National Association of Manufacturers (1940), and the Temporary National Economic Committee (1938–1941). About a year ago the President of the United States, by Executive Order No. 8977, created the National Patent Planning Commission "to conduct a comprehensive survey and study of the American patent system, and consider whether the system now provides the maximum service in stimulating the inventive genius of our people in evolving inventions and in furthering their prompt utilization for the public good; whether our patent system should perform a more active function in inventive development; whether there are obstructions in our existing system of patent laws, and, if so, how they can be eliminated; to what extent the Government should go in stimulating inventive effort in normal times; and what methods and plans might be developed to promote invention and discoveries which will increase commerce, provide employment, and fully utilize expanded defense industrial facilities during normal times."

NATIONAL PATENT PLANNING COMMISSION

The National Patent Planning Commission has concerned itself to date mainly with studies bearing upon some of the more important questions of policy arising in connection with the patent system itself, such as the problems arising in the granting of patents, their adjudication and use. It has endeavored to clarify conceptions regarding the standard of patentability which would insure adequate encouragement to creative research and ingenuity, as well as the attraction of capital essential for the development and commercialization of inventions. In its first report to the President it will make suggestions for legislation to aid in enhancing public and judicial confidence in the American patent system while fully protecting the inventor and investor.

The National Patent Planning Commission is also under-

(*Continued on page 258*)

Recent Developments in
CARBIDES *Vs.* HIGH-SPEED STEEL

By H. A. OLDENKAMP and JAMES McFADYEN

THE WARNER & SWASEY COMPANY, CLEVELAND, OHIO

BECAUSE the field of metal cutting is its specialty, the authors' company has naturally sought to keep an accurate and close check on all types of cutters used in its own shop. The performance of these cutters has been followed closely by a centralized tool-control department. This department, which was started a few years ago for the main purpose of servicing carbide tools, has been largely responsible for the development of the applications for the various cutting materials. It is operating twenty-four hours a day, servicing between 2500 and 3000 carbide cutters during this period for the entire shop.

The tool-control and shop-tool-design departments work closely together in choosing the proper cutter for a job after it has been issued by the drawing room. The tool-design department consults with the tool-control department on the proper cutter, and a design is decided upon. Carbide, of course, is always given first consideration for the job because of its many advantages, except for the limitations mentioned later in this paper.

Jobs already in the shop are constantly being converted to carbide wherever possible. The procedure is to arrive at a proper design for the cutter by experiment. The feeds, speeds, and other data are then recorded and turned over to the shop-tool-design department for permanent recording and the drafting of the cutter.

CUTTING METALS AND THEIR GENERAL APPLICATIONS

The various cutting materials used and their percentages are stellite, 5 per cent; high-speed steel, 50 per cent; and carbides, 45 per cent. Carbides, because of the higher speeds possible through their use, are being used more widely.

The general application of carbides in a machine-tool shop can be listed as follows:

Type 44-A carbide or equivalent: For general-purpose work on cast iron.

Type 883 carbide or equivalent: For precision work on cast iron, especially precision boring. It should be used on scale-free material and is not recommended for heavy intermittent cuts.

Type 78-B carbide or equivalent: For general-purpose work on steel.

There are a great many cases where the use of carbides has not yet proved practical. For instance, high-speed steel is generally recommended for steel-milling operations, although successful straddle- and face-milling, using carbides on steel, is almost out of the experimental stage. Carbide cutters have been found to be unsuitable for finishing the noses of the spindles for turret lathes of company manufacture. This work is still being done with high-speed steel, because the finishing must be carried out at too slow a speed for carbide cutters. Higher speeds generate heat, causing inaccurate work.

High-speed-steel cutters are still superior to carbides on turret lathes for extremely heavy intermittent cuts. For cutoff operations, it has not been practical to use carbides, because the cutter is usually not wide enough to prevent weaving. In making multiple cuts, where relatively large and small diameters are turned simultaneously, the small diameter must be turned with high-speed steel, because the surface speed of the small diameter is too slow for carbides. The larger diameter, however, can be turned with a carbide tool.

In spite of these limitations, the turret-lathe department of the authors' company uses about 80 per cent carbides in its tools.

High-speed steel is more desirable than carbides on planers for making deep slots, because of the danger of the tools' not clearing the work on the return stroke of the planer table. On side slots, where the operator must clear the tool from the work by hand, it is more practical to use high-speed steel, from the standpoint of safety both to the operator and the tools. Short strokes are also impossible with carbide tools, because the momentum of the planer table with higher speeds will not allow the table to reverse quickly enough for most jobs on which the short stroke must be used.

RECENT APPLICATIONS OF CARBIDES

Some new applications of carbide cutters are shown in the accompanying illustrations. Fig. 1 shows a "centering body" being processed in a turret lathe. Previously, this job was "hogged out" by high-speed steel in two cuts. The metal is now being removed in one pass by two carbide cutters, one set slightly in advance of the other in a special toolholder. Obviously, the time was reduced considerably in comparison with the previous method.

Fig. 2, besides being an excellent carbide application, is an example of how a number of duplicate parts can be made with

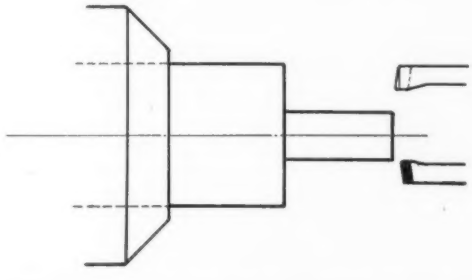


FIG. 1 CENTERING BODY BEING PROCESSED IN A TURRET LATHE BY USE OF TWO CARBIDE CUTTERS

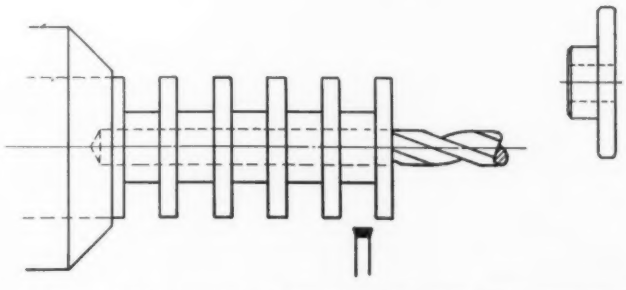
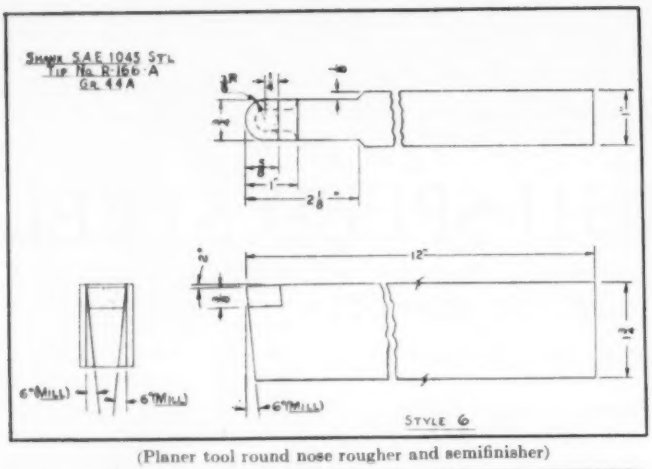
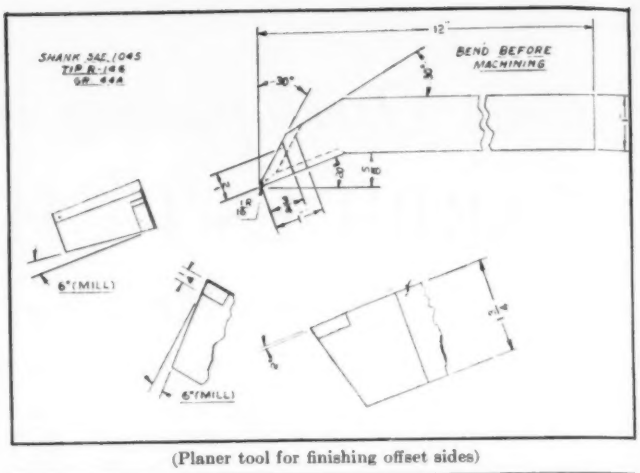


FIG. 2 SIX GEAR BLANKS IN SERIES MADE WITH ONE CHUCKING OPERATION

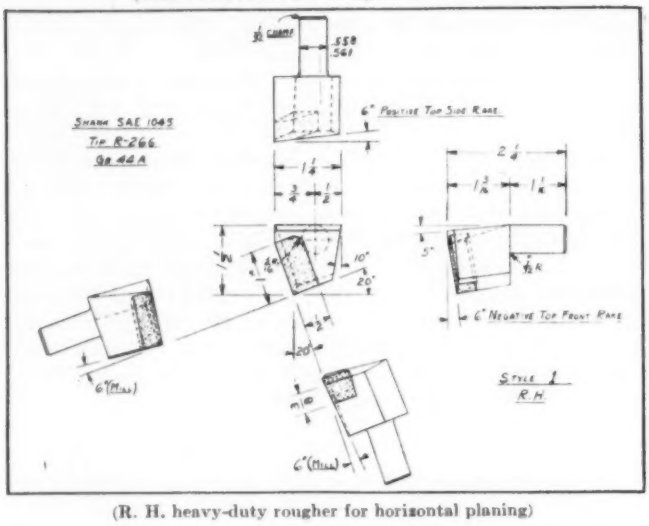
Contributed by the Production Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



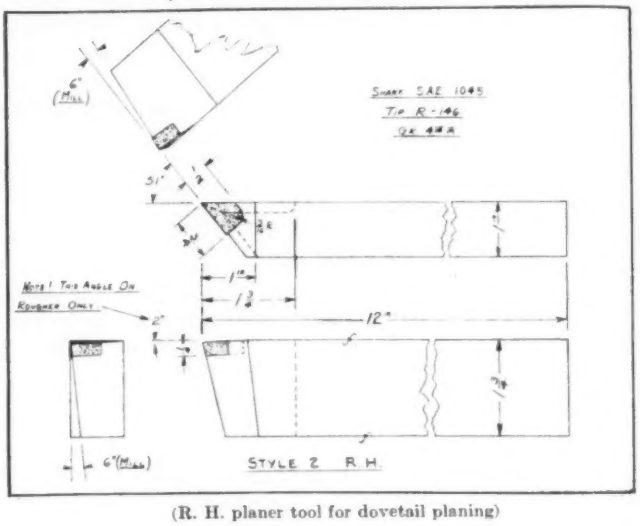
(Planer tool round nose rougher and semifinisher)



(Planer tool for finishing offset sides)

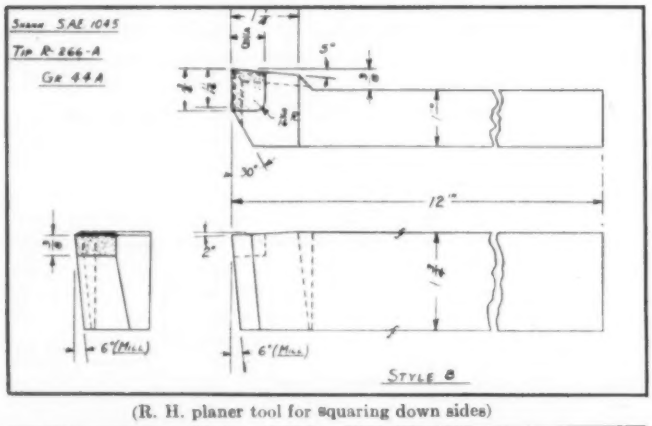


(R. H. heavy-duty rougher for horizontal planing)

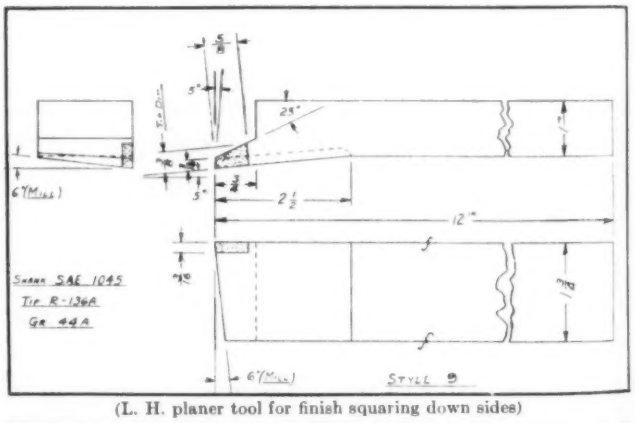


(R. H. planer tool for dovetail planing)

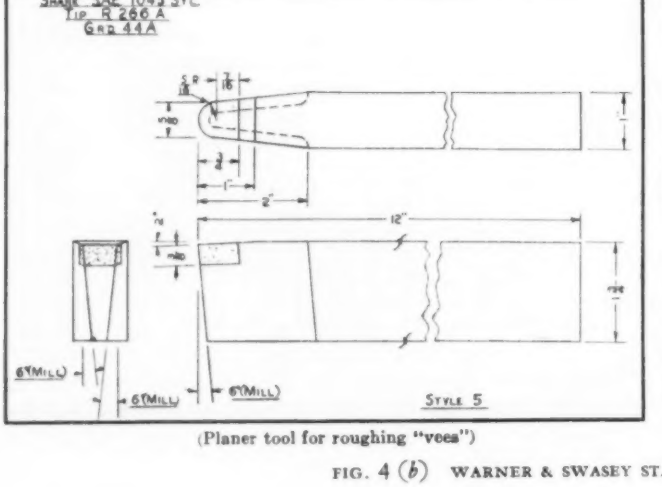
FIG. 4 (*a*) WARNER & SWASEY STANDARD CARBIDE PLANER CUTTERS



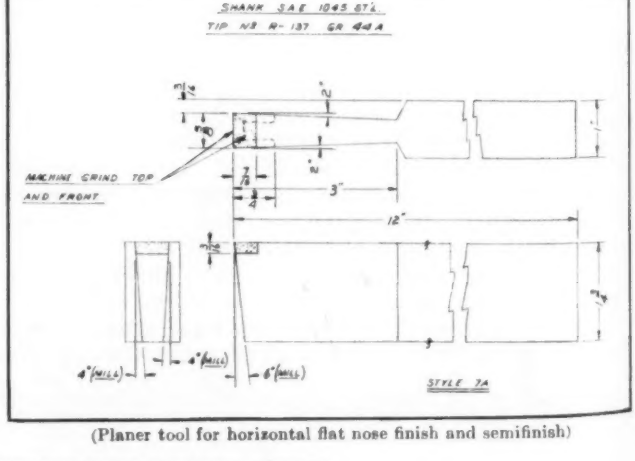
(R. H. planer tool for squaring down sides)



(L. H. planer tool for finish squaring down sides)



(Planer tool for roughing "vees")



(Planer tool for horizontal flat nose finish and semifinish)

FIG. 4 (*b*) WARNER & SWASEY STANDARD CARBIDE PLANER CUTTERS

one chucking operation on a turret lathe. Here is a series of six gear blanks made with one chucking operation. The boring is done by a drill, at the same time that a cross-slide tool cuts the hubs. After the hubs are formed, the blanks are cut off and the bar is moved forward again in the machine for cutting six more blanks.

The part shown in Fig. 3 is a "hex turret" being processed for one of the company's machines. The groove shown was previously "hogged out," using a bent high-speed-steel tool, which was a very slow process requiring several passes. By the use of carbide tools, the roughing cut is now taken in one pass, reducing the time for the job considerably.

For some time carbide-tipped tools have been used successfully on boring machines. In one particular instance on a large lathe bed, the over-all time was reduced from 15 hr to 5 hr. Carbides have proved less expensive in their initial cost, compared with high-speed-steel boring bars. Repairs to carbide-tipped boring bars are also less expensive.

Our most recent application of carbides has been on planers, where a 30 to 40 per cent time saving has been effected, including setup. Carbides are now being used successfully on planers for roughing, finishing, cutting shallow grooves and dovetails.

Successful application of carbides to planers is based on getting the proper angles on the cutters, so that the tools can withstand the impact of the cut. In order to achieve uniform production, we were forced to establish standard angles for our cutters. Details of these cutters are presented in Figs. 4 (*a* and *b*), for the use of the industry. It is not recommended that they be used exactly as shown, the illustrations being given to serve as a guide only. Slight changes may have to be made to suit the particular job and the machine.

PRECAUTIONS IN USING CARBIDES

There are many precautions which must be observed in the use of carbides; otherwise success in their use will not be attained. Attention must be paid first of all to the system employed for introducing carbides into the shop. The matter of grinding and setup for carbides is so different from that of high-speed-steel cutters that we cannot depend upon the ordinary operator to do this job correctly. Hence, we have found that a centralized tool-control system is essential. As a matter of fact, the centralized tool-contol system is also recommended for high-speed-steel cutters to obtain maximum efficiency.

The grinding of carbides should be done by hand wherever possible, because the amount of heat developed in the tip from the grinding can be controlled more readily. Clearance angles should be held to a minimum to give as much support as possible to the cutting edge.

Setting up a carbide job must be done carefully to attain maximum efficiency. Correct feeds and speeds are essential. A carbide tool wears more quickly, operating at too slow a speed, than when the work is turned too fast. At slow speeds, the tip seems to build up rapidly, which makes the cutter dull and will cause breakage. When the work is turned too rapidly, the cutter becomes pitted, and a crater develops just behind the cutting edge. This condition continues until the edge breaks.

Ordinarily, the shank material recommended is in the range of 0.45 to 0.65 per cent carbon steel. However, we have had good success using cast-iron shanks, except in places where considerable shock was likely to be experienced. The angles can be cast, saving considerable milling time on large cutters. In general, the cutter holders for carbides must be much sturdier than for high-speed steel.

CONSERVATION OF HIGH-SPEED STEEL

There are many methods of brazing or cementing high-speed-steel tips on mild-steel shanks in order to conserve high-speed steel. It is the authors' opinion that such methods are satisfactory and require very little equipment. However, it is believed that the process of butt-welding high-speed-steel ends

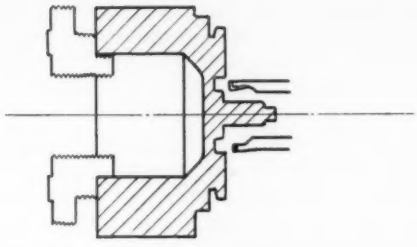


FIG. 3 HEX TURRET BEING PROCESSED WITH CARBIDE TOOLS

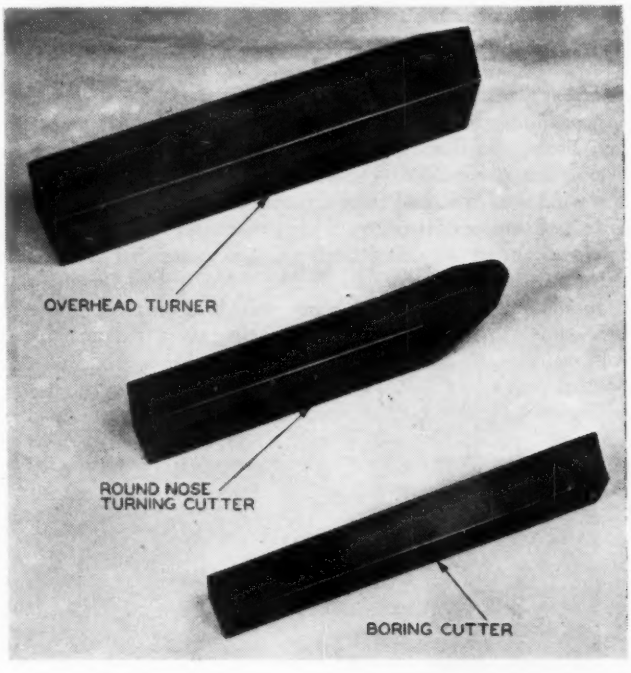


FIG. 5 TYPICAL BUTT-WELDED CUTTERS

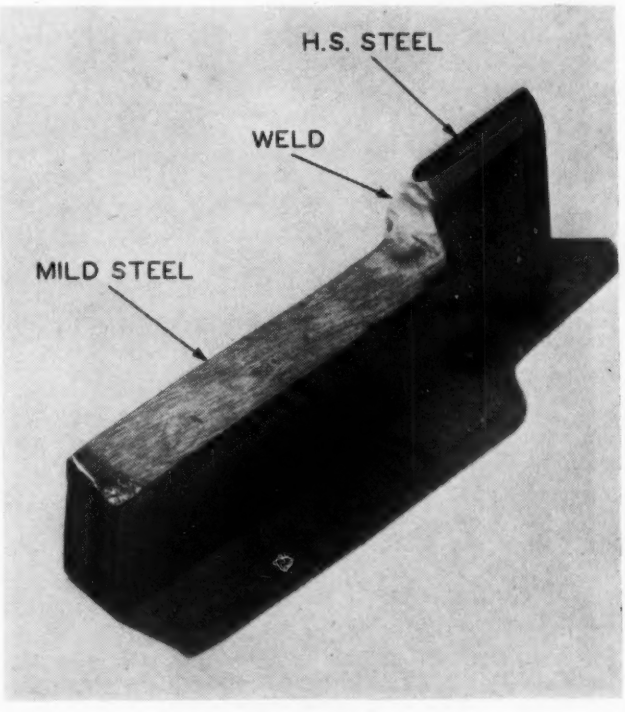


FIG. 6 FORGED WELDED OFFSET CUTTER

to mild-steel shanks for the fabrication of lathe tools, a process used widely in England, is well worth considering, even though the initial cost of the equipment is higher. With this thought in mind, several experiments have been conducted with some indication of successful application of the process.

A number of tools were welded and given severe tests in the authors' shop. Of eighteen sample tools, there were two unintentional failures. In one case, the failure was attributed to overloading the tool; the other was the result of a surface check caused by heat-treating. Both breaks occurred well into the tool steel and might have been avoided had the samples been properly aligned when welded. Because of the misalignment, there was a small shoulder between the tool steel and mild steel on the bottom face of the cutter. This shoulder undoubtedly created stress concentrations, which subsequently caused the failures.

The remaining tools were tried on various jobs with no unexpected failures. Several cutters were overloaded purposely and broken to determine where the breaks would occur. In every case, the breaks were well into the tool steel away from the weld, and the mild steel actually bent before the tool steel failed. Samples of these tools are shown in Fig. 5.

Fig. 6 shows an offset tool which was welded and forged through the weld before hardening. No special forging procedure was followed. The work was done in the company's blacksmith shop, the smith merely being given a blueprint and told to forge the tool. After forging, the tool was hardened to 64 Rockwell C in the tool steel, and 27 Rockwell C in the shank.

The offset tool was then placed in a No. 3-A turret lathe and a cut was taken on X-1315 steel at a surface speed of 114 sfm. The depth of cut was $1^1/_4$ in. and feed 0.0167 in. An attempt was made to take a $1^1/_2$-in. depth of cut; however, the X-1315 steel could not be held in the chuck. No damage was done to the tool.

The fact that the welds are forgeable is of importance, because the welding can be simplified. No special dies or holding fixtures need be made for odd-shaped tools. The pieces can be forged into any desired shape after welding.

SUMMARY AND CONCLUSIONS

In summarizing this paper, we have shown the advantages of using carbide in place of high-speed steel, emphasizing our recent success in its application to planers. The limitations of carbides must be observed and considered carefully, and, as a result, carbides must be used with discretion to attain maximum production. On the other hand, we should not assume that the present limitations are in any way permanent and thus be deterred from making further investigations to remove the obstacles.

The precautions outlined in this paper can be overcome successfully and should not be confused with the limitations of application, which we do not as yet know how to overcome.

The co-operation of the operator is important and must be achieved if carbides are to be applied to advantage.

With regard to the methods of conserving high-speed steel, tests conducted so far indicate that the butt-welding of tool steel to mild-steel shanks for making lathe cutters can be done satisfactorily.

FIG. 7 TYPICAL PLANER SETUP ON WHICH CARBIDES HAVE BEEN APPLIED SUCCESSFULLY

CUTTING METALS
From the USER'S POINT *of* VIEW

By L. B. DORSNER

MANUFACTURING ENGINEER, WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, EAST PITTSBURGH, PA.

THE user of cutting tools is concerned with uniformity, improved performance, and lower tool cost per cubic inch of metal removed. He is also interested in longer tool life and more production between grinds, particularly on automatic and semiautomatic machines where each tool change involves a considerable amount of down time.

The use of skilled machine adjusters to care for tools and setups on a group of machines, having relatively unskilled attendants on an increasingly large portion of present-day manufacturing output, is limited more by a shortage of skilled adjusters than of ordinary operators, hence the demand for better tools and better performance.

CLASSES OF CUTTING MATERIALS

The cutting materials available for the tool user fall naturally into four classes: (1) Carbon and low-alloy tool steel; (2) high-speed steel, both the tungsten and molybdenum types; (3) the cast-alloy group; (4) the sintered carbides of tungsten, titanium, tantalum, singly or in combination.

In the first class, the straight-carbon tool steels and improvements of them by small additions of various alloys are too well known to warrant comment. They will always have a place for low-activity and fine-finishing applications as metal-cutting materials. With this group of materials, the user is interested in standardization of the many varieties into a few definite analyses and types.

Among the high-speed steels, the most popular is 18-4-1 tungsten high-speed steel (18W-4Cr-1V). In recent years the 18-4-2, now unobtainable, or so-called "double-vanadium" type, has been developed and extensively used for heavy-duty applications. The tungsten-cobalt group obtained by varying additions of cobalt to tungsten high-speed steel has also found many applications. Another group of high-speed steels, in which molybdenum is substituted for all or most of the tungsten, has been known for many years, but its commercial application was long retarded by the abundance of tungsten and the more precise requirements for manufacturing and heat-treatment of the molybdenum steels. Present-day temperature-measuring instruments and furnace designs have made molybdenum steels practical. The cutting off of foreign sources of tungsten by the war has recently brought the molybdenum group into prominence, and it is now being used in large tonnages particularly in the so-called "double-six" type.

The third class, or cast-alloy group, came into considerable use for heavy-duty cutting about the time of the first world war. Recently, a number of new cast alloys have been introduced by the manufacturers, permitting considerable extension of their application.

In the sintered-carbide class, tungsten carbide, which was the first to be developed, quickly found application for machining cast iron and abrasive materials but had little success in machining steel. By the addition of other carbides, such as titanium and tantalum, carbide grades have been developed which have great efficiency in steel cutting.

Contributed by the Production Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

APPLICATIONS OF CUTTING MATERIALS

In general, there are definite applications for all four classes of materials. The production capacity under proper application is increasingly higher from class 1 (carbon steel) to class 4 (sintered carbide). However, the ability to stand abuse is in the reverse direction. Most of the failures in the use of the newer materials are due to insufficient power and speed, lack of rigidity in the machine or part to be machined, improper design of the tools themselves, or incorrect selection of the proper grade to be applied.

Sintered carbides are almost exclusively tipped tools.
Cast alloys are used as tipped tools and tool bits.
High-speed steels are used as solid tools, tipped tools, tool bits.
Carbon steels are practically all used as solid tools.

It has been the practice of the author's company for many years to tip a very large percentage of its single-point cutting tools. Until recently, the smallest tipped sizes were $^3/_4 \times 1^1/_2$ and $1^1/_4$ in. square shank sizes. However, it is planned to tip sizes $^5/_8 \times 1^1/_4$ and 1 in. square in some of the more active styles. The larger sizes of milling cutters, reamers, etc., are made with inserted blades or with a low-carbon-steel shank, welded or brazed to a high-speed-steel body. By extending these practices to smaller sizes, the company has been able to save large quantities of the scarce high-speed steels.

Another case is a combination of cast-alloy or high-speed steel with sintered-carbide-tip tools. This combination works very successfully on the same operation, the cast-alloy tools or high-speed steels working on the small diameters and the carbide tool operating on the outside diameter. Hence, both the cast alloy, or high-speed steel, and carbide tools operate at their best respective speeds.

Stellite and other intermediate cast alloys are being used successfully, particularly on automatic screw machines where, in many cases, the carbide tools were not successful because of insufficient speeds on small diameters, and the use of sulphurized cutting oil. For example, on an automatic screw machine that had a few years of service and was worn to some degree, a larger order of $^{11}/_{16}$-in-diam screws made from nickel-steel bar S.A.E. 2330 was being machined. With the 18-4-1 type of tool, it was necessary to regrind the tool every two to three hours or between 60 and 75 pieces; whereas with the cast-alloy type of tool, it was necessary to grind the tool only once in 16 hr, or 375 to 400 pieces. Another example is machining a bolt made from $^3/_4$-in. hexagon, commercial, hard-copper bar. Using cast-alloy cutting tools, production amounts to better than 2200 pieces per grind as against 200 pieces from the 18-4-1 type cutting tool.

The cast alloys cannot be machined except by grinding, and therefore do not lend themselves to the more intricate shapes of cutting tools. But setups using cast alloy where possible in combination with high-speed-steel tools in the same setup will reduce materially the amount of attention required in adjustments and tool grinding, thereby greatly increasing production, even where rigidity of machine or the material to be cut will not permit increased cutting speeds.

Sintered carbide was first introduced as a metal-cutting

material for cast iron and nonferrous material in the straight-tungsten-carbide grades. Later by the addition of titanium or tantalum, success was obtained in cutting steel. Where working conditions will permit, the use of carbide will greatly increase production.

The steel-cutting grades, that is, the tungsten-titanium-carbide type, and tungsten-tantalum-carbide, or a composition of both, containing all three metals, tungsten, titanium, and tantalum, have made great progress as steel-cutting tools.

In using the sintered-carbide type of cutting tool, the machine operator should exercise great care of the tool, which should be kept as sharp as possible. For example, a dull point deteriorates rapidly and the tip may chip or break, making it necessary to grind away a large part of the carbide tip to sharpen and restore the tool to its proper shape.

For best performance of any carbide tool, considerable attention should be given to the tip and shank size; the larger the tip and shank, the greater will be the capacity of the tool to absorb heat and withstand shock.

It is most important to select the proper grade of carbide. The supplier should be advised whether the tool is to be used for continuous or intermittent cutting so that he may furnish the proper grade. Another factor that should be given careful consideration is in the selection of proper clearance angles. It is important to keep all of the angles down to a minimum which will permit free cutting. Doing this gives added support for the cutting edge, which in turn increases tool life.

OPERATING PRECAUTIONS TO BE OBSERVED

In cutting steel, it is important to use the correct type of chip breaker when cutting with tantalum- or titanium-carbide-tip tools, because of the high cutting speeds. Without a chip breaker, the chip will flow in straight ribbon form. Such straight chips are difficult to handle and are dangerous to the operator. In many instances they twist around the tool, causing it to break. It is, therefore, the author's practice to grind a small groove in the face of the tool to serve as a chip breaker. This type of chip breaker causes the chip to curl and break off in small sections.

The various styles of cutting tools, as well as the different kinds of material to be cut, require separate consideration for a chip breaker. If the grooves are ground too deep or too wide and not on a radius from the cutting edge, it is found that the chips are not curled, and the high pressure exerted by the high speed will cause the cutting edge to break.

Some chip breakers are made with an additional piece which is either brazed or clamped on the top of the tool. In many cases, this additional piece will curl up the chip into small spirals which break off. However, the high pressure exerted by the hot chip eventually wears off this additional piece and the chip again flows in a long ribbon form. Another disadvantage of the separate chip curler is the tendency of the rapidly moving chip to force itself between the chip breaker and the tool face, causing breakage of the cutting edge or destruction of the chip curler. Grinding the chip breaker into the top has given the best results.

It is impossible to recommend the definite speeds and feeds for carbide tools to apply in all cases. High speeds are possible for light finishing cuts, but better results have been obtained by the author with rather conservative speeds and feeds when using carbides for stock removing. The following feeds and speeds represent average practices of the author's company:

Cast-iron roughing cuts, up to $^3/_4$ depth of cut: 160 to 240 surface feet per minute (sfm); feed per revolution, up to $^3/_{32}$ in.

Cast-iron finishing cuts: 180 to 240 sfm; feed per revolution, $^1/_{32}$ in.

Steel S.A.E. 1050, continuous cutting up to $^5/_8$ depth of cut: 200 to 250 sfm; feed per revolution, $^1/_{32}$ in.

Steel S.A.E. 1050, intermittent cutting up to $^3/_8$ depth of cut: 150 to 200 sfm; feed per revolution, 0.022 in.

Heat-treated alloy steels, continuous cutting up to $^1/_2$ depth of cut: 175 to 200 sfm; feed per revolution, 0.025 in.

Copper, 600 to 800 surface feet per revolution; feed per revolution, 0.011 to 0.018 in.

Proper tool-grinding procedure is a matter of great importance. Wherever possible, centralized tool grinding to carefully supervised standards for clearance angles and finish of cutting edge should be provided. Many cases of failure to obtain good results are directly traceable to poor tool grinding. This is particularly the case with carbide tools. Time spent in obtaining a uniform smooth cutting edge will pay big dividends.

American Engineer and the War Effort

(Continued from page 252)

taking a number of studies which have as their objective a policy for government with reference to the acquisition, control, and management of patents owned by Government, those acquired by purchase and seizure, those belonging to employees of Government, and patents growing out of research by Government agencies and by its contractors. Our Government now controls thousands of patents, and many important patents will result from war research which is now being carried on for the Government in war industries and at educational institutions. The policy of Government with reference to these patents is of major concern to our profession and to American industry. I shall welcome suggestions from you and from my other friends in the engineering profession as to a practical policy for our Government with reference to patents it now owns or controls, which will fully protect American industry and which will adequately reward the inventor.

The most important phase of the assignment of the National Patent Planning Commission is covered in the last part of the President's order and relates to the problem of stimulating inventive talent for the benefit of the war effort, and for the purpose of utilizing the expanded war industries during the postwar period. What should our Government do to stimulate inventive effort and what plans and incentives should be developed to encourage research and invention which will increase commerce, provide employment, and fully utilize defense industrial facilities during normal times? This problem is of special concern to the engineering profession as well as to the public at large, if the technical skill and equipment which we are now building up to meet the needs of the war effort are utilized most effectively to provide full employment and a higher standard of living when peace becomes a reality. Radio emerged from the first world war to become a great industry. It is conceivable that the inventive talent of Americans, if fully stimulated, will provide many novel devices and create many new industries which will enable us to win the peace that follows the war. In connection with this important part of the task of the National Patent Planning Commission you, the members of the engineering profession, can be of particular assistance.

Difficult and uncertain times are ahead. We must not, however, allow present world conditions to undermine our faith in humanity, in the ability of our own engineering profession to solve difficult problems, or in the future of this, the most civilized and humane democratic nation in all history. This great country, which has had for 153 years a good government, the most creative people in the world's history, and the rugged idealism which has stood for the noblest and best in human conduct, is bound to demonstrate the superiority of a free, courageous, and united people in its struggle against the wrong ideology of our misguided enemies. Let us pull together so that victory may be assured for the United Nations and let us use our talents as engineers to aid in winning the war quickly and in perfecting a plan for the enhancement of American ideals and American standards in a world at peace.

One Method of Meeting CUTTING-TOOL MATERIAL PROBLEMS

By H. A. TOBEY

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

IN a period that demands maximum machine production on one hand and conservation of materials on the other, The Timken Roller Bearing Company like all other manufacturers using many types of machine tools was faced with these two contradictory problems. The output of the machine-tool builders is taxed many times beyond normal capacity and, in spite of their excellent record in meeting this emergency, deliveries are usually months behind the actual need. At the same time, scarcity of the vital alloying elements, tungsten, vanadium, chromium, cobalt, molybdenum, and others used in the manufacture of cutting tools demands their conservation to the fullest extent.

The first phase of meeting the machine-tool scarcity is to tool the existing machines with cutting tools which will give maximum machine production. In order to accomplish this, a study of each type of machine and its product is required to determine: (1) What tool or tools controls the machine output? (2) From what type of material or materials should the tools be made?

In meeting the cutting-tool problem, three general classifications of materials are available for consideration:

1 High-speed steel; also broken down into four general types, i.e., tungsten type, molybdenum type, cobalt type, and the newer 4 to 6 per cent molybdenum 4 to 6 per cent tungsten type.

2 The cast alloys, selling under trade names such as Stellite 2400, Tantung, and many others.

3 The sintered carbides of tungsten, tantalum, and titanium with a binder which is primarily cobalt.

CONCERNING HIGH-SPEED STEEL

Starting with the high-speed steels purchases are generally limited to 75 per cent of one standard type and 25 per cent for the remaining types, with the added problems of maintaining inventory in a sufficient number of sizes and procurement of replacement stock. To meet these problems the author's company has established a complete program of making practically all types of cutting tools with the high-speed steel in the form of inserts or tips, cemented to a medium- or low-carbon-steel shank or body. The cementing process is comparatively simple and can be done in any plant having suitable furnaces for heat-treating high-speed steel. The cementing is actually done during the heat-treating operation.

Cementing of high-speed-steel tips or inserts on ordinary steel shanks or bodies not only gives much wider latitude in the choice of the type of high-speed steel for a given application due to a reduction of approximately 75 per cent in total consumption of the high-speed steel but it also opens an untapped source for this vital material. This source is in the form of obsolescent tools, tools ground down to the extent that they are too short for the toolholder, broken tools, and bar ends. All of these in the past were considered as scrap, now they are sorted as to grade, annealed (except that the bar ends do not require annealing), and reprocessed into tipped tools. All types of lathe and boring-mill-turning tools, forming tools, boring tools, radius tools, reamers, cut-off blades for automatic machines, and numerous other tools are successfully made with this method.

A second method of conserving high-speed steel is butt-welding. Although not used as extensively as cementing, we do butt-weld double-end boring tools. A small piece of high-speed steel butt-welded on either end of a 1-in-square × 4-in-long S.A.E. 1020 steel body produces as many pieces on a given screw-machine setup as a solid high-speed tool. Another application is to butt-weld a $^1/_2$-in. × 1-in. × 1-in. piece of high-speed steel to a piece of S.A.E. 1020 steel, $^1/_2$ in. × 1 in. × 4 in., then forge the high-speed steel to a $^1/_{10}$-in-thick cut-off blade. This not only saves high-speed steel but also promotes standardization of toolholders.

A third method of conserving high-speed steel is tool design. One of the most important changes in tool design accomplished by the author's company has been the redesigning of toolholders on a number of applications to replace circular forming tools with flat formers. In one specific case, a circular former required a piece of high-speed steel 6 in. round × 3 in. long. The flat former replacing this tool requires a piece of high-speed steel $^1/_2$ in. thick × 3 in. wide × 4 in. long cemented to an S.A.E. 1020 steel body.

CAST-ALLOY TIPS AND SINTERED CARBIDES

The cast alloys for cutting tools are applied almost entirely in the form of inserts or tips brazed on common steel or cast-iron shanks. It has been the author's experience that the cast cutting tools have a place in the tooling program between the high-speed steels and the sintered carbides. They allow and require greater spindle speeds than high-speed steel and are more easily ground than sintered carbides.

Tool tips made from the sintered carbides of tungsten, tantalum, and titanium with proper machine conditions will permit maximum machine speed. However, these tool tips require different combinations of the carbides as well as binders for different service conditions. It has been found that the supplier, when informed of service conditions, can greatly assist in the selection of proper grades.

APPLYING CUTTING TOOLS TO MACHINES

In applying the cutting tools to the machines, one representative example is the machining of a forged ring approximately $10^1/_2$ in. OD × $8^1/_2$ in. ID × 2 in. long made from S.A.E. 4320 steel. The finished machined part has a straight outside surface with a $^1/_4$-in-high × $^7/_{16}$-in-wide flange at one end. The inside is tapered, having a 30-deg included angle. The machining setup for this forging consists of two 6-D Potter & Johnston

Contributed by the Production Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

automatic lathes. The tooling for the first operation machine consists of the following:

One 1-in-square × 6-in-long tool for rough-boring.
One 1-in-square × 6-in-long tool for finish-boring.
One 3/4-in. × 1-in. × 6-in-long tool for chamfering the first face.
One 3/4-in. × 1-in. × 4 1/8-in-long tool for rough-turning the outside diameter.
One 1-in. × 1 1/4-in. × 6-in-long tool for rough-facing the first face.
One 1-in-square × 6-in-long tool for finish-facing the first face.
One 1-in-square × 6-in-long tool for turning the outside radius.

All tools used on this setup are sintered-carbide-tipped tools.

The tooling for the second operation machine consists of the following:

One 1-in. × 1 1/4-in. × 6-in-long tool for rough-turning the outside-diameter rib.
One 1-in-square × 6-in-long tool for chamfering the second face.
One 3/4-in. × 1 1/4-in. × 5 1/2-in-long tool for facing the second face.
One flat forming tool for finish-forming the outside diameters.

All tools in this setup, except the flat former, are sintered-carbide-tipped. The flat former was made from high-speed steel, cemented to an S.A.E. 1020 steel body.

The flexibility of this type of machine permits machining speeds ranging from 300 to 350 sfm with 0.020-in. feed on the sintered-carbide tools and a reduction to 80 to 90 sfm with 0.008-in. feed for the high-speed-steel finish-forming tool. At this point, we should consider the question of why not make the forming tool with a sintered-carbide insert? In answering that question, three things must be taken into account: (1) The insert is 2 in. wide and formed to finish the 1/4-in. × 7/16-in. rib as well as the straight outside surface. (2) The grinding of sintered carbides requires special wheels. The author has found a diamond-impregnated wheel the most satisfactory. (3) At best the rate of grinding is relatively slow.

To date, it has been found that grinding large formers of this type to shape from a rectangular piece of sintered carbide is impractical. On the other hand, only one to three formers of this specific part are required to maintain production, and for that reason it is impractical for the producers of sintered carbides to furnish tips which were formed before sintering.

Another representative example of a tool setup is the machining of a 7.160-in-OD × 5.236-in-ID tube made from S.A.E. 4620 steel. The finished product is 7 in. at its largest outside diameter, 6 in. at its small outside diameter, with a 1/4-in. × 5/16-in. rib at the large end, and 1/8-in. × 3/16-in. rib at the small end. The bore is straight, 5 1/2 in. diam, and the over-all length is 2 in.

The machine used to make this part is an 8-in. 4-spindle automatic screw machine. The tool setup consists of the following:

First position:
1 Flat former for roughing the outside diameter
1 Rough-facing tool
1 Rough-boring tool
Second position:
1 Flat former for roughing the outside diameter
1 Rough-facing tool
1 Rough-boring tool
Third position:
1 Rough radius tool
1 Flat former for finishing the outside diameter
1 Floating reamer for finishing the bore
Fourth position:
1 Finish-facing and radius tool
1 Cut-off

There is nothing extraordinary in the types of tools used in this setup until we consider their manufacture. These tools were processed in the following manner: All the forming tools were made with high-speed-steel inserts, cemented on S.A.E. 1020 steel bodies. All the facing tools and all the radius tools were made with high-speed steel, cemented on S.A.E. 1020 steel shanks. The double-end boring tools were made by butt-welding a piece of high-speed steel on either end of a 3/4-in-square × 4-in-long S.A.E. 1020 steel shank. The cut-off tool was made by butt-welding a 1/2-in. × 1-in. × 1-in. piece of high-speed steel to a 1/2-in. × 1-in. × 4-in. piece of S.A.E. 1020 steel; then the high-speed-steel end was forged to a 1/8-in-thick cutoff blade. The floating double-edge reamer was taken from a quantity of worn-out reamers, ground flat on the outside surfaces, and a thin piece of cast-alloy cutting-tool material was brazed on each cutting face. The reamers were then ground to finished shape and size.

The foregoing details reveal the fact that every tool in this setup was either tipped or butt-welded, with a resultant saving of approximately 75 per cent of the cutting-tool material over solid high-speed-steel tools, with no sacrifice in machine production.

Now the question arises: Why not use sintered carbides or more cast-alloy tools to increase the production of this machine? In this tool setup, the same problem is encountered as in the Potter & Johnston setup. Either large forming tools must be obtained in special shapes, or the high manufacturing cost precludes their use. The flat formers are the tools that establish machine speed. With this constant spindle speed in all positions the remaining tools do not require the use of the sintered carbides and cast alloys, nor is there sufficient spindle speed for efficient operation of these alloys.

Advances in Plastics During 1942

(*Continued from page 247*)

D. Telfair, and R. U. Haslanger, *Modern Plastics*, vol. 19, July, 1942, pp. 65–69; also Proceedings of the A.S.T.M., vol. 42, part II, 1942.

95 "Mar Resistance of Plastics," by L. Boor, *Modern Plastics*, vol. 20, Sept., 1942, pp. 79–83; also Proceedings of the A.S.T.M., vol. 42, part II, 1942.

96 "Creep Tests on Cellulose Acetate," by Wm. N. Findley, *Modern Plastics*, vol. 19, Aug., 1942, pp. 71–73, 114; also Proceedings of the A.S.T.M., vol. 42, part II, 1942.

97 "Acid and Alkali Resistance of Plastics," by J. Delmonte, A.S.T.M. Bulletin No. 119, Dec., 1942, pp. 11–15; also *Modern Plastics*, vol. 20, Dec., 1942, pp. 91–94, 146, 148.

98 "Bearing Strength: Plastics and Plywood," by James Bond, Trans. A.S.M.E., vol. 65, Jan., 1943, pp. 9–14; also *Modern Plastics*, vol. 19, July, 1942, pp. 70–73, 110.

99 "Behavior of Plastics under Vibrations," by B. J. Lazan, *Modern Plastics*, vol. 20, Nov., 1942, pp. 83–88, 136, 138, 140, 142, and 144.

100 "Physical Properties of Laminated Plastics," by R. W. Barber, MECHANICAL ENGINEERING, vol. 64, Dec., 1942, pp. 888–890.

101 "Strength of Plastic-Bonded Plywood," by G. B. Parsons, Trans. A.S.M.E., vol. 65, Jan., 1943, pp. 1–7; also *Modern Plastics*, vol. 19, Aug., 1942, pp. 74–79, 110, 112, 114.

102 "The Effects of Continued Heating on the Mechanical Properties of Molded Phenolic Plastics," by T. S. Carswell, D. Telfair, and R. U. Haslanger; presented before A.S.M.E. Rubber and Plastics Group, Dec. 3, 1942.

103 "Mechanical Tests of Cellulose Acetate; Part III," by W. N. Findley; presented before A.S.M.E. Rubber and Plastics Group, Dec. 3, 1942.

104 "Physical Properties of Polystyrene as Influenced by Temperature," by T. S. Carswell, R. F. Hayes, and H. K. Nason, *Industrial and Engineering Chemistry*, vol. 34, Apr., 1942, pp. 454–457.

105 "Effect of Solvents Upon Solid Organic Plastics," by J. Delmonte, *Industrial and Engineering Chemistry*, vol. 34, June, 1942, pp. 764–770.

106 "New Methods for Mechanical Testing of Plastics," by L. H. Callendar, *British Plastics*, vol. 13, Apr., 1942, pp. 445–454, 456–458; May, 1942, pp. 506–514, 516, 518–519.

107 "Impact Strength of Plastic Sheet," by C. S. Myers, *Modern Plastics*, vol. 20, Oct., 1942, pp. 81–87, 116, 118.

108 "Some Observations on the Mechanical Testing and Flow Properties of Industrial Plastics," by E. G. Couzens and W. G. Wearmouth, *Journal of the Society of Chemical Industry*, Trans. Section, vol. 61, May, 1942, pp. 69–74.

109 "Phenol-Formaldehyde Plastics Under Conditions of Bending Fatigue," by D. Warburton-Brown, *Plastics*, vol. 6, July, 1942, pp. 210–218.

110 "1942 Book of A.S.T.M. Standards," American Society for Testing Materials, Philadelphia, Pa.

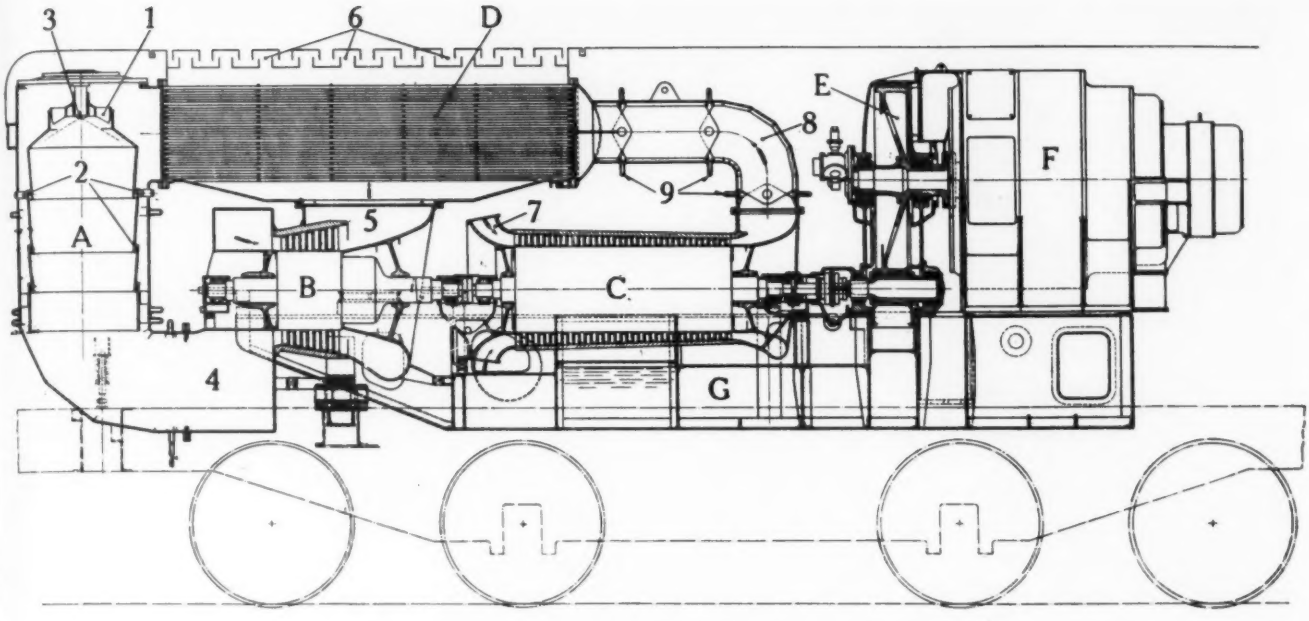


FIG. 1 ARRANGEMENT OF GAS-TURBINE LOCOMOTIVE POWER UNIT

GAS-TURBINE LOCOMOTIVE *With* ELECTRICAL TRANSMISSION

By PAUL R. SIDLER[1]

IN 1939, Brown, Boveri & Co., Ltd., Baden, Switzerland, undertook the construction of the first gas-turbine locomotive for the Swiss Federal Railways. The outbreak of the war delayed somewhat the progress on this novel vehicle, but in spite of the many difficulties and shortages in labor and materials, it was eventually completed in the fall of 1941.

Again, owing to the war conditions in all countries surrounding Switzerland, a severe shortage of liquid fuel has prevailed, so that it has not been possible to arrange for as great a number of test runs over as wide a variety of lines as would otherwise have been desirable. However, several road tests of sufficient duration and over various tracks have been made, which have demonstrated not only that the guarantee conditions had been met but that the expectations were exceeded in many instances.

Before considering these test results, it might be well to recall briefly the basic layout of a gas-turbine power plant.

Referring to Fig. 1, the main elements designated with letters are: *A*, combustion chamber; *B*, gas turbine; *C*, axial compressor; *D*, air preheater; *E*, reduction gear; *F*, direct-current generator with built-in exciter; *G*, auxiliary frame.

The compressed and preheated air is introduced into the combustion chamber as combustion air through the nozzle ring (1), partly as cooling air through slots (2). The fuel enters through the injection nozzle (3). Combustion gas and cooling air mix in chamber (4) and form the driving gas proper, which expands through the gas turbine. The exhaust gases, which still have a high temperature, pass the air preheater from (5) to (6) where they leave through the locomotive roof. The air inlet to the compressor is at (7). The outlet-air duct from the compressor to the heat exchanger is provided with several expansion joints to allow for different expansion in the gas-turbine set and the preheater.

Built into the same frame with the main generator *F* is an auxiliary generator for electric train heating, rated at 200 kw.

In passing, it seems desirable to point out that electrical transmission was selected because its operation is well known from experience, while hydraulic or mechanical transmissions for such outputs do not appear to have been developed beyond the experimental stage and would therefore introduce considerable uncertainty. The fact that this locomotive with electrical transmission has been in operation for more than a year, while projects involving hydraulic transmission, which were advanced in other quarters, have not progressed beyond the paper stage, certainly confirms the correctness of this choice.

The complete power unit was assembled on a strong auxiliary frame which could be lifted into the locomotive as a whole, as shown in Fig. 2.

The completed locomotive, with perhaps too-conservative exterior lines, is shown in Fig. 3, as it started out on the first trip under its own power, in September, 1941.

By way of contrast consider the "Heilmann Locomotive," Fig. 4, built in 1896, with a 6-cylinder steam engine of 1350 hp and electrical transmission furnished by Brown, Boveri. Naturally this locomotive is no longer active, but it was the first vehicle with successful electrical transmi sion through eight

[1] Resident Engineer, Brown, Boveri & Co., Ltd., New York, N. Y. Mem. A.S.M.E.

Contributed jointly by the Oil and Gas Power and Railroad Divisions and presented at the Annual Meeting, New York, N. Y., Nov. 30–Dec. 4, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

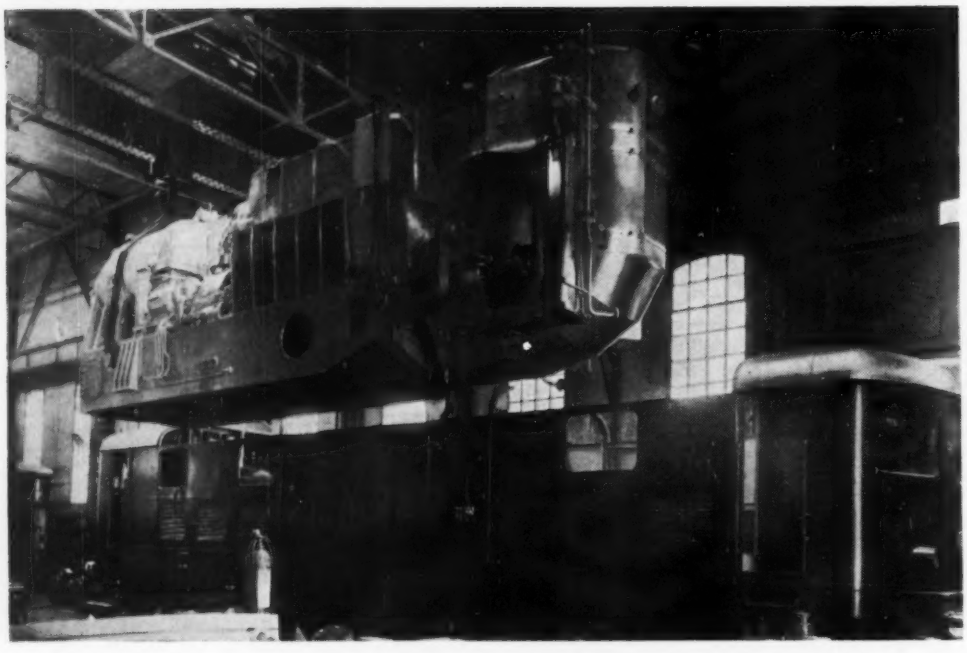


FIG. 2 POWER UNIT MOUNTED IN AUXILIARY FRAME

axle motors, giving it a speed of 60 mph. Also note the streamlining.

The governing system of the gas-turbine locomotive was adapted with a few changes from the well-tried pressure-oil-operated field-regulating system which has been in satisfactory operation on many Diesel-electric locomotives for a number of years.

The somewhat simplified diagram, Fig. 5, shows the operating stands at both ends with the main controllers. By moving the controller from step to step, the engineer regulates the supply of fuel to the burner and the speed of the gas-turbine set; and through the speed governor also the generator-field regulator which in turn influences the electrical output. The proper co-ordination of all these devices is assured by oil relays operated from a common pressure oil supply, which during starting also lubricates all bearings.

The main operating characteristics of the gas-turbine power unit are plotted in Fig. 6, from measurements taken during acceptance tests. Fig. 6 is set up as follows:

Abscissa: Output in horsepower with full load at 2200 hp
Curve 1: Thermal efficiency in per cent (maximum about 18 per cent at about 80 per cent rating)
Curve 2: Generator speed in revolutions per minute (812 rpm at full load)
Curve 3: Gas temperature at turbine inlet in deg F (1112 F at full load)
Curve 4: Air pressure after compressor (about 44 psi at full load)

The principal data for the locomotive, prescribed in the original order, are as follows:

Continuous output of power unit at generator coupling: 2200 hp at a turbine speed of 5200 rpm and a generator speed of 812 rpm

Tractive effort rating at wheel tread:

At starting	29,000 lb from 0 to 16 mph
One hour	17,000 lb at 30 mph
Continuous	11,000 lb at 45 mph
Maximum speed	70 mph
Maximum service weight including fuel	101 short tons
Maximum axle load	17.6 short tons

The last two requirements were imposed by the contemplated service of the locomotive on branch lines where the traffic density has not justified electrification. For main-line service, the weight and axle load could be about 15 per cent higher.

From the test runs actually carried out three sets of figures for different terrain may be of interest, as given in Table 1.

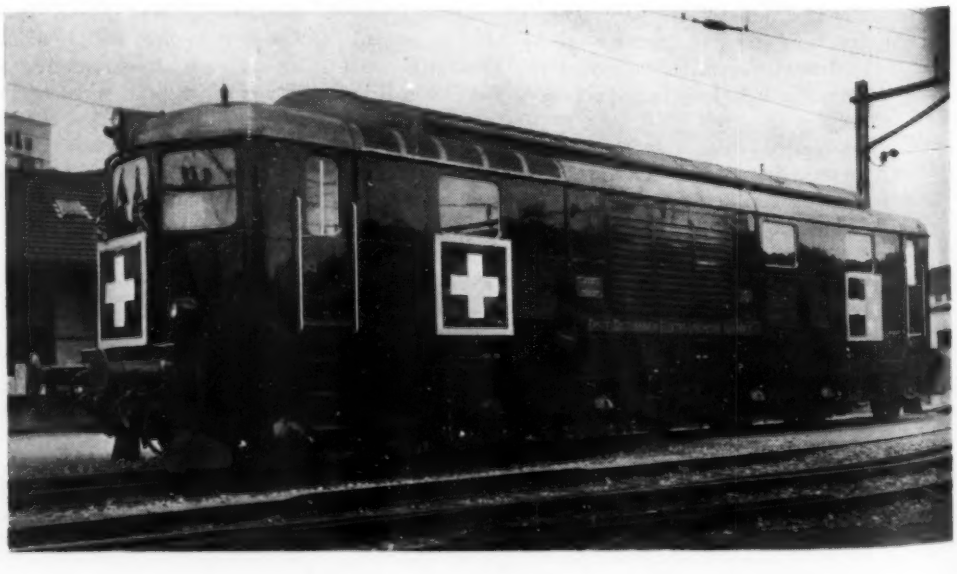


FIG. 3 GAS-TURBINE LOCOMOTIVE ON FIRST TRIAL RUN IN 1941

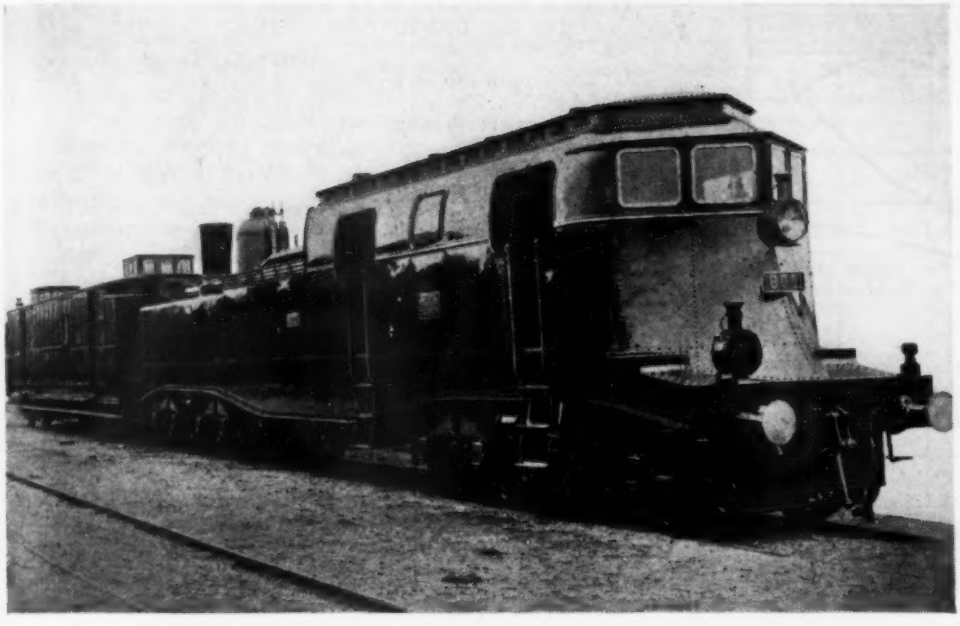


FIG. 4 HEILMANN STEAM LOCOMOTIVE OF 1896

TABLE 1 RESULTS OF TEST RUNS

Test run	No. 1	No. 2	No. 3
Length of the line, miles	100.2	60.4	41.55
Total weight of train, short tons	430	313	313
Change of elevation, ft	+906	+1358	—266
Average ruling grade, per cent	0.171	0.4265	—0.121
Running time including stops, min	147.5	101.5	52
Number of stops	9	7	1
Running time without stops, min	130.5	83.5	50
Average speed without stops, mph	46	43.5	49.7
Output at generator terminals, kwhr	1597.6	818.5	428.3
Input at generator coupling, kwhr	1735.5	892.5	466
Fuel consumption (Bunker C), lb	2805	1783	998
Fuel consumption, lb per hp-hr	1.2063	1.4923	1.5973

On another occasion, acceleration tests with a total train weight of 321 short tons (including locomotive) showed the conditions given in Table 2.

From data obtained during the test runs, improvements and refinements for application to future locomotives have been developed, notably in the direction of improved fuel consumption at partial loads.

TABLE 2 RESULTS OF ACCELERATION TESTS WITH TRAIN WEIGHT OF 321 TONS

Grade, per cent	Speed, mph	Time measured, sec	Time guaranteed, sec	Acceleration, mph per sec
0	56	112	150	0.5
1.2	37.3	97	150	0.385
1.8	24.85	90	100	0.276
2.6	18.65	100	100	0.1865

In 1941, E. E. Chapman of the Atchison, Topeka and Santa Fe Railway Company, presented a paper[2] which gave an inter-

[2] "Operation of Steam Vs. Diesel-Electric Locomotives," by E. E. Chapman, MECHANICAL ENGINEERING, June, 1941, pp. 451–455.

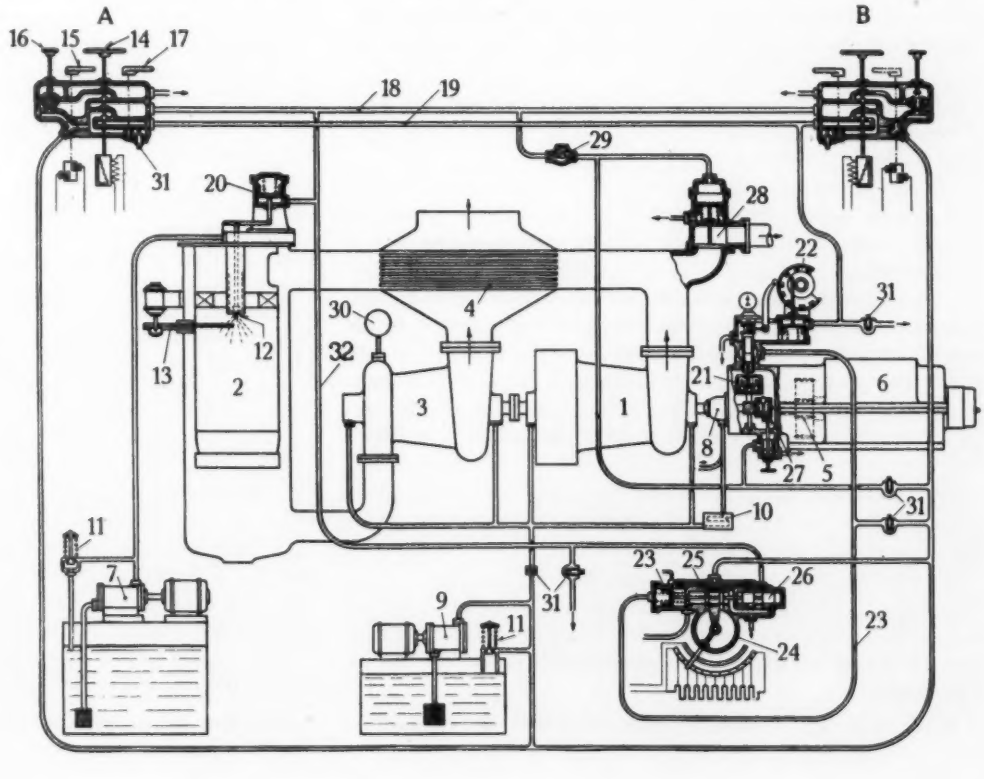


FIG. 5 DIAGRAM OF GAS-TURBINE LOCOMOTIVE GOVERNING SYSTEM

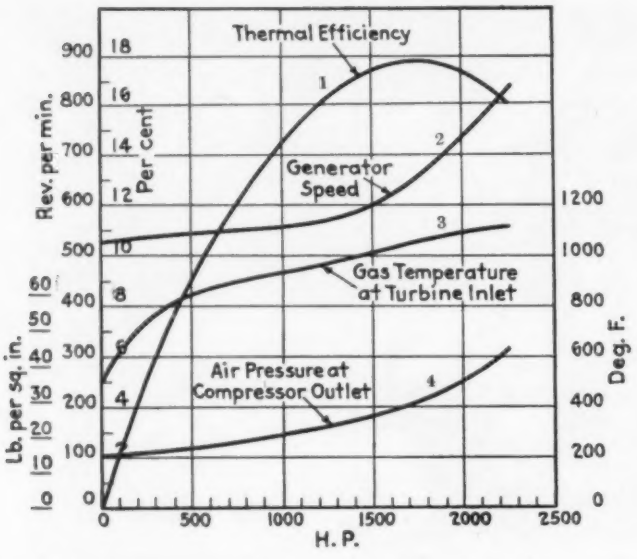


FIG. 6 OPERATING-CHARACTERISTICS DETERMINED FROM TEST DATA

esting comparison on steam and Diesel-electric locomotives. Although the gas-turbine locomotive has not as yet accumulated sufficient operating experience to establish all these characteristics accurately, it is of interest to tabulate some of Mr. Chapman's findings and add the corresponding data for the gas-turbine locomotive. It must be admitted that some of the figures for the latter are based upon careful estimates rather than upon operating experience over extended periods of time. The comparison is given in Table 3.

Some further comments in connection with several of the characteristics given in Table 3 would seem to be appropriate:

(*a*) Cost of gas-turbine locomotive is based upon production in quantity similar to Diesel or steam locomotives.

(*c*) As the gas-turbine locomotive has no reciprocating parts, its time out for repairs should be the smallest of the three. One may, of course, question the durability of the turbine blading. For the conservative gas temperatures chosen, experience with a large number of exhaust-gas turbines and continuous-combustion turbines shows practically no wear of this blading even after several years of operation.

(*d*) The gas-turbine locomotive requires no water but does need a considerably larger fuel tank than the Diesel locomotive; thus requiring a longer time for refueling.

(*e*) As the gas-turbine locomotive has no reciprocating parts and works below critical speeds throughout the range, it should allow even higher-schedule speeds than the Diesel locomotive.

(*f*) Neither the Diesel nor the gas-turbine locomotive has unbalanced weights; the gas-turbine locomotive has a lower weight per horsepower, thus less track wear.

(*j*) The equality of fuel costs for Diesel and gas-turbine locomotives is only valid for oil-producing countries or other regions where the cost of fuel oil is about one half that of Diesel oil.

(*k*) The lubricating-oil costs for the gas-turbine power plant are negligible; the axles and the running gear require of course the same amount of lubrication as in other types.

(*l*) The small water requirements for the auxiliary Diesel engine for starting the gas turbine has not been considered, as this set will only run a few minutes each day; it is contemplated that air-cooled auxiliary Diesel engines will be used in future locomotives.

While it is clear from this comparison that the gas-turbine locomotive is not as yet a serious competitor for the Diesel locomotive, it is also evident that, in certain classes of service, it will show marked advantages. It should be particularly suitable for express service over long distances in areas where water is scarce, and where there is a considerable difference in the costs of Diesel oil as against ordinary fuel oil.

TABLE 3 COMPARISON OF STEAM, DIESEL-ELECTRIC, AND GAS-TURBINE LOCOMOTIVES

	Steam	Diesel	Gas-turbine
(*a*) Approximate cost per hr, dollars	35	87	65
(*b*) Efficiency at drawbar, per cent	6–8	26–28	15–16
(*c*) Mileage per year	180,000	250,000	Over 250,00
(*d*) Time for tanking and refueling	Greatest	Least	Small
(*e*) High scheduled speed	Lowest	Higher	Higher
(*f*) Track wear	Large	Less	Least
(*g*) Power braking	None	Full power	Full power
(*h*) Approximate life in years	30	15–20	30
(*i*) Maintenance	Lower	High	Least
(*j*) Fuel costs, per cent	100	50–75	50–75
(*k*) Lubrication costs, per cent of fuel costs	10	20–30	Less than 5
(*l*) Water costs, per cent of fuel costs	10	Small	Nil
(*m*) Starting effort	Minimum	Larger	Larger

Discussion

COMMENT BY RICHARD HEROLD[3]

The author has given us a report about a most interesting development in the field of transportation. His principals, Brown, Boveri & Co., Ltd., are to be congratulated on having succeeded, in spite of difficult wartime conditions, in building this gas-turbine locomotive. The builders' technical skill is emphasized by the fact that this gas-turbine locomotive, the first of its kind, has embarked directly on an extensive program of tests, which tests have given results so good that they can already be compared with the performances of existing types of motive power.

Up to now, the steam locomotive has endeavored to defend its position against the inroads of the Diesel. Now, it is the Diesel locomotive's turn to be on the defensive. While this new situation may be a cause to rejoice for the fiery adherents of the steam engine, it should not be looked upon frowningly by the friends of the Diesel locomotive, as it will spur the builders of this latter type to still more rapid progress. Whether the gas-turbine locomotive will become a serious competitor of the Diesel locomotive depends upon various factors, some of which are the same as those which made possible the great success of the Diesel-electric locomotive.

The most important of these factors is availability. The high availability of the Diesel-electric locomotives makes it possible for a certain number of such units to replace a larger number of steam locomotives. The gas-turbine locomotive will unquestionably have a very high availability, due to the simplicity and serviceability of its components. As the gas-turbine locomotive will hardly ever be advantageous in switching services, let us consider only main-line operation. Reports compiled by the A.A.R., covering periods of many months, indicate that, in this kind of service, the average availability of American Diesel-electric locomotives is better than 90 per cent; in some instances it is 98 or even 100 per cent. Under such circumstances, the gas-turbine locomotive will not be afforded a chance to outdistance the Diesels. It may do just as well, but it can do no better. It appears, therefore, that availability is not a factor in competition.

With regard to first cost purchase price, the gas-turbine locomotive has decided advantages. The author has quoted a price

[3] President, Sulzer Bros., Ltd., New York, N. Y. Jun. A.S.M.E.

of $87 per hp for the Diesel-electric locomotive; this figure has appeared in various reports, in the past, and it is certainly correct. But his figure of $65 per hp for the gas-turbine locomotive is an assumption. The price difference between the two types may not be as high as $22. Moreover, the price of Diesel-electric locomotives can be reduced by redesign. At the present time, the competing American designs follow the same general patterns; this may not necessarily remain so.

The higher first cost of the Diesel-electric locomotive is compensated by its lower fuel consumption or, in other words, by its better thermal efficiency. Under test conditions, a Büchi supercharged 4-cycle locomotive Diesel engine has a thermal efficiency of 38 per cent, or even better. Through the use of suitable control arrangements, this figure can be maintained from full load to 1/4 load. The gas turbine has, under test conditions and at its best point, a thermal efficiency of 17 per cent maximum. At part load, this efficiency drops rapidly; at 1/4 load it is only 10 per cent. Therefore, the gas turbine uses, at its best point, more than twice as much fuel as the Diesel. Even if the gas turbine should be able to burn cheaper lower-grade fuels than the Diesel, which is open to question, it could hardly run as economically as the Diesel. The efficiency of the gas turbine can of course be increased by various recuperators, but these devices would increase the first cost of the locomotive, and the gain in operating economy would be compensated by higher amortization costs.

Lubricating-oil consumption is a point which is all in favor of the gas turbine, even if the author's figure of 5 per cent of fuel cost is misleading because fuel consumption of the gas turbine is more than twice that of the Diesel. Lubricating-oil consumption figures published for some types of Diesel-electric locomotives are indeed surprisingly high. There is room for improvement, and it is understood that considerable progress has been made of late. But, even so, the gas-turbine locomotive will remain far ahead of the Diesel locomotive in that respect.

A point which reacts strongly against the gas-turbine locomotive is its sensitiveness to the temperature of the ambient air, or intake air. It is of course the compressor which is responsible for this situation. The horsepower absorbed by the compressor and developed by the turbine is a multiple of the net power obtainable at the coupling. This entails that a slight drop in the efficiency of the compressor will noticeably reduce the net power and the over-all efficiency. If the power of the gas-turbine locomotive is taken as 100 per cent at 68 F, it drops to 77 1/2 per cent at 100 F, whereas for the Diesel the difference is only 5 per cent. As, in this country, a locomotive must unavoidably operate under climatic conditions which vary a great deal, it follows that the design must be based upon the most adverse conditions which may be encountered; and from this it follows that the gas-turbine locomotive must be overdimensioned 20 per cent for normal conditions.

Summing up, the gas turbine in its present stage of development appears to have the following main advantages in comparison with the Diesel-electric locomotive: lower first cost, greater simplicity, lower lubricating-oil consumption. The disadvantages are high fuel consumption, unfavorable operation at part load, dependence upon temperature.

The coming years will no doubt bring many heated arguments between the proponents of the gas-turbine locomotive and the Diesel locomotive. It is not impossible that someday, in a rather distant future, the two types will be merged into one. Already the builders of the gas-turbine locomotive have made a small concession to Diesel manufacturers by installing a Diesel as a starting engine. On the other hand many engines in Diesel locomotives have a small gas turbine driven by exhaust gases. The relative importance of the two plants may become equal. The gas-turbine plant wastes a great deal of energy in cooling the hot combustion gases to a temperature acceptable for the turbine blades. If the combustion were transferred into a compression-ignition engine, the loss in thermal energy would be much smaller.

In a recent paper, F. Oederlin of Sulzer Bros. referred to an interesting case in the development of the supercharged 2-cycle engine; when supercharged to 85 psi, the engine develops just enough power to drive the supercharging compressor, and it does not deliver any power at the coupling. Such an engine is nothing but an efficient producer of hot gases; the high-temperature part of the combustion and expansion process takes place in the Diesel and is used to drive the compressor, while the lower part takes place in the gas turbine. The Diesel with compressor corresponds to the boiler of a steam plant. A certain number of such "boilers" could feed a single turbine driving a single generator. As emphasized before, this solution is by no means just around the corner and it will require a great deal more research work.

COMMENT BY J. T. RETTALIATA[4]

The author's company is to be congratulated for its pioneering development work on the gas turbine, especially in this critical time of war. The operating data, presented by the author regarding the gas-turbine locomotive, are fairly complete but the writer would appreciate being informed of the amount of surface used in the heat exchanger as well as the pressure drops on the air and gas sides, and the over-all heat-transfer coefficient obtainable.

In this country Allis-Chalmers has conducted an engineering study[5] of the gas turbine as a drive for locomotives of larger output than that discussed by the author. Various arrangements have been considered including electrical and hydromechanical transmissions, with the latter type appearing to have certain weight and efficiency advantages. The study indicates that a 5000-hp gas-turbine locomotive with hydromechanical transmission would have a total operating specific weight of 112 lb per hp at the axle and would be capable of speeds up to 120 mph. An arrangement diagram of this locomotive is shown in Fig. 7 of this discussion.

In his paper, the author gives a maximum service weight of 101 tons or 202,000 lb for the Brown, Boveri gas-turbine locomotive. With an assumed efficiency of 85 per cent for the electrical elements of the transmission, the total service specific weight for this locomotive is 108 lb per hp at the axle. Even though the locomotive used in the Allis-Chalmers study is designed for a maximum speed of 120 mph, it can be seen that its specific weight is very close to that of the Brown, Boveri locomotive which has a maximum speed of 70 mph.

In the interest of weight reduction and also to achieve more uniform distribution of weight, the power plant of the locomotive studies by Allis-Chalmers has been divided into two units of 2500 hp each. In each unit, a two-turbine design has been adopted; one turbine furnishes sufficient power to drive the compressor only, and the excess gas generated operates the other turbine, thereby providing propulsive power to the locomotive. The use of separate turbines improves the partial-load performance, since the compressor and its driving turbine can operate independently at their optimum speed regardless of the speed of the locomotive.

The hydromechanical transmission, consisting of a torque converter and hydraulic coupling for low and high speeds, respectively, affords a high tractive effort at starting without a sacrifice in maximum speed. Control of the locomotive speed is accomplished by a combination of manual and governor regulation of the fuel burned in the combustion chamber and also by throttling the gas supplied to the power turbine.

---

[4] Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Jun. A.S.M.E.

[5] "An Engineering Study of the Combustion-Turbine Locomotive," by J. L. Ray, Allis-Chalmers Bulletin No. B-6066, Sept. 6, 1939.

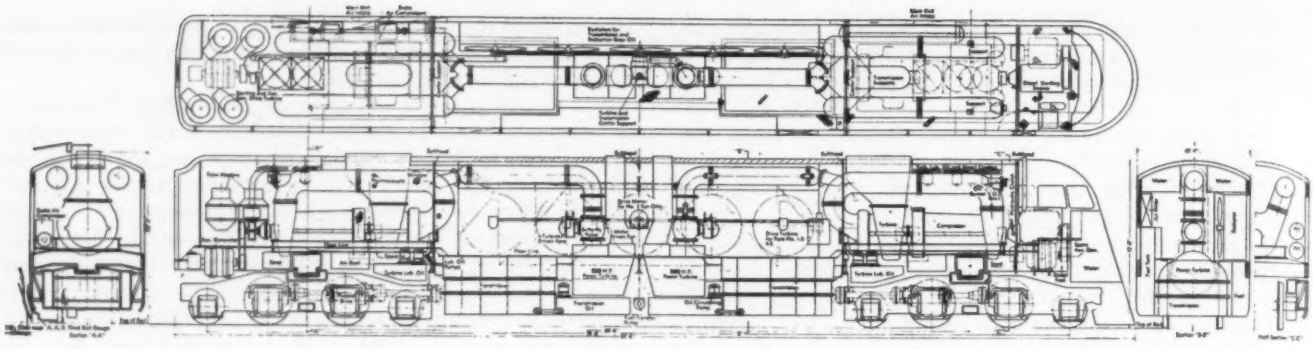


FIG. 7 ARRANGEMENT DIAGRAM OF PROPOSED 5000-HP GAS-TURBINE LOCOMOTIVE

The transmission for each turbine consists of two sets of torque converters and hydraulic couplings, so that each driving axle of a truck has its connected set. Thus the individual hydraulic units, which operate at 1535 rpm, when the locomotive speed is 90 mph, are about 3 ft in diam and transmit about 1200 hp each. Accordingly, they do not exceed either in size or speed similar units which have been built previously.

The tractive effort of the locomotive at the drawbar at starting is 78,000 lb, while at 100 mph it is 11,000 lb.

AUTHOR'S CLOSURE

In reply to Dr. Rettaliata's question, the author regrets that he does not have available accurate information on the surface of the heat exchanger. However, mention of the temperature conditions in the air preheater may at least partly answer the question. At full load of the gas turbine, the air temperature is increased from 201 to 284 C, while the temperature of the gas through the preheater decreases from 366 to 279 C.

Again, test data on the electrical equipment have not been obtainable, but from the figures, shown in Table 1 of the paper, on the test runs, it can be established that the average efficiency of the electric generator for the varying load during a run is between 91.5 and 92 per cent. This machine is built according to the latest practice for railroad equipment and certainly has a full-load efficiency of around 95 or 96 per cent.

From Mr. Herold's very interesting remarks, the author would select only such matters for comment as (1) efficiency, (2) fuel costs, (3) influence of air temperature.

1 The sloping efficiency curve of the gas turbine at partial loads is, of course, an inherent characteristic of turbo-type machinery. It has already been indicated in the paper that data have been developed for improving this situation. Such an improvement by simple means will consist in operating the gas turbine at higher inlet-gas temperature at partial loads. In this manner, the efficiency at these points can also be improved and a flatter curve will be obtained.

An improvement in the full-load efficiency of any gas-turbine power plant depends primarily upon the availability of metals which will permanently stand higher gas temperatures and still can be machined by ordinary means. Due to the lack of such steel alloys for commercial purposes in Switzerland about three years ago, which lack continues to this day because of the war, all of the gas turbines built by Brown, Boveri in 1939, and since that time, were designed for a maximum gas temperature at the turbine inlet of 600 C or 1112 F.

Development work on materials which can stand higher temperatures has, of course, been going on for quite some time in various countries and has no doubt even been speeded up by the requirements of war production. It is thus a safe prediction that materials for higher-temperature work will be commercially available after the war.

An increase in the allowable continuous gas temperature at the turbine inlet will immediately bring very favorable results in the over-all efficiency of the gas turbine. Not only will the temperature drop through the gas turbine and thus its output be increased, but at the same time the quantity of air needed for cooling the hot combustion gases down to the temperature limit permissible for the turbine will be proportionately reduced, thus also reducing the power consumption of the compressor. As the net output of the gas turbine is the difference between the power developed at the gas-turbine coupling and the power consumed by the air compressor, there will be a double gain from any allowable increase in the temperature, and the over-all efficiency will increase at a rate about double that of the temperature.

It has been noted that the maximum thermal efficiency of the gas-turbine power plant on this locomotive is about 18 per cent at about $^3/_4$ load. If a gas temperature of 1500 F can be allowed at the turbine inlet, the thermal efficiency will immediately increase to 29 to 30 per cent, i.e., it will approach more nearly that of a Diesel-electric unit. Naturally, the author's company will take advantage of these developments in metallurgy without, however, sacrificing any reliability, and it can thus be expected that gas-turbine units for locomotive or other applications which are to be built after the war will be considerably more efficient than the present pioneer units.

2 Mr. Herold doubts whether the difference in fuel cost between Diesel oil and Bunker C oil is in the ratio of 2 to 1, but the author has figures from a survey undertaken on fuel costs in the major ports of the world by several European shipping companies, before the war started. This survey shows average fuel costs as follows:

If the cost of Bunker C oil is taken as 1, the cost of gas oil is 2.09 and that of Diesel oil 2.26; all are based on the same weight.

3 It is true that the net output of a gas-turbine power plant varies with the temperature of the surrounding air. This is particularly due to the inherent characteristics of the axial compressor. Its power consumption increases with the air temperature, thus leaving a smaller effective output of the power plant, but the reverse is also true. When the gas-turbine locomotive is operated during wintertime, with its lower average air temperature, the extra output obtained from the gas turbine will be more than sufficient for heating the entire train electrically. On railroads where electric train heating is not in general use, this extra energy could, of course, easily be converted into steam through an electric boiler installed on the locomotive.

On runs across high mountain ranges the gas turbine will again develop more power as it reaches higher altitudes, which is a most desirable feature for negotiating the grades; to cite an example:

If the net output of the gas turbine is 2000 hp at 68 F air temperature, it will be about 2600 hp at 32 F and about 3280 hp at minus 4 F.

CONSERVING *the Use of* CRITICAL MATERIALS

Developing Scrap-Saving Methods as a Means of Supporting the War Effort

By B. D. KUNKLE

VICE-PRESIDENT, GENERAL MOTORS CORPORATION, DETROIT, MICH.

THE thought uppermost in the mind of every good American citizen today is, "How can I help most to win the war?" The field through which definite contributions can be made is broad. It not only includes the boy who leaves his work and takes up arms in defense of a great human cause, it also includes everyone who helps support that boy in carrying out the purpose to which he has dedicated his life. We in industry are among those who "help support." We produce the things he has to have at the front.

In fulfilling this obligation to produce for our boys on the battle line, one of the most serious problems which confronts us is the limited supply of certain critical materials. Great as our resources are, there are today definite limitations on the quantity production of essential war products because of the lack of these materials. It is for this reason that the subject of industrial salvage has become so important.

In our production processes, as completely as we feel they are developed, there is still a substantial amount of material waste. The more we can cut down this waste by reducing the production of unnecessary scrap, the greater the contribution we can make to increasing production.

While the use of scrap is essential in many of our prime-material processes, reducing the amount of scrap made is of even greater importance.

STUDYING PRODUCTION PROCESSES TO REDUCE MATERIAL WASTE

In the case of many fabricated articles and parts, our art of processing has not yet advanced to the point where any great savings in scrap are possible. In the case of others, however, waste can be substantially reduced by concentrated and co-ordinated study and effort. This is particularly true with respect to implements of war, because of the obvious fact that in the past we have devoted our efforts largely to the manufacture of articles of peace. Probably all of us can cite examples of large forgings of alloy steel which weigh 3 times the finished part into which they are machined. In contrast, in the manufacture of automobiles, for example, we were accustomed to figure that the over-all loss of material ran approximately 35 per cent of the total raw material required in the production of a car. And that was in the period before our highest degree of processing had been achieved.

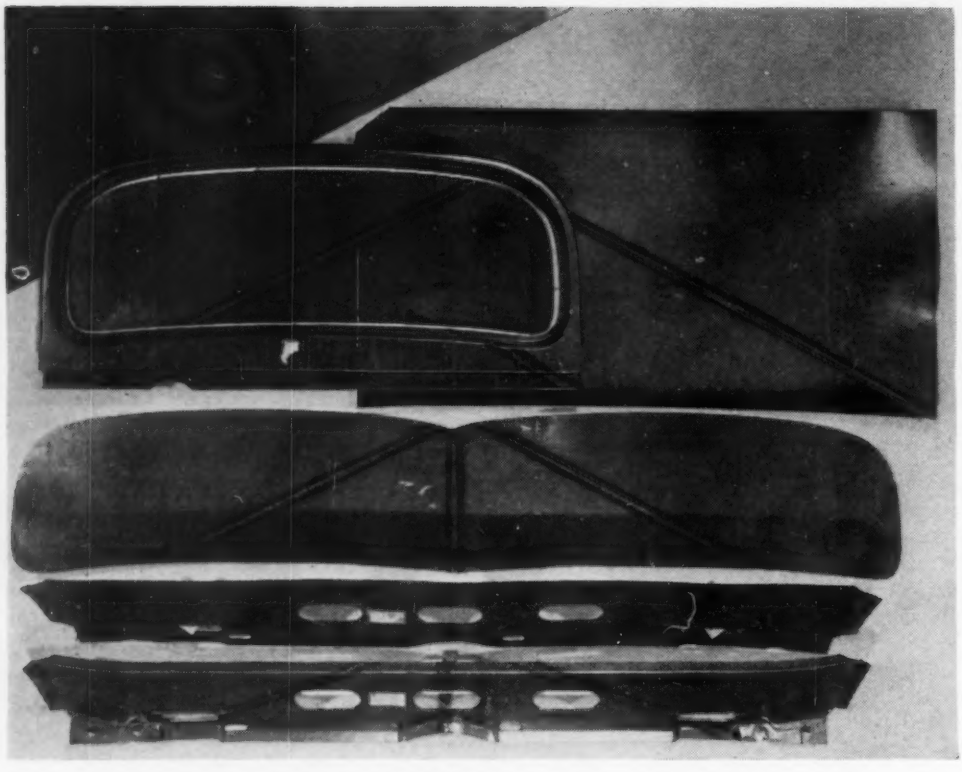
In the manufacture of war products, the situation has been practically the reverse. In one of our machine-gun plants, our first study showed that for every 3 lb of material introduced in production only 1 lb of machine gun resulted. Cases such as this naturally suggested to our manufacturing staff the desirability of giving this phase of our war job careful attention. Fortunately, in connection with our peacetime production, we had been conducting an organized and comprehensive program for the more efficient utilization of raw materials. While perhaps we cannot claim that 100 per cent of the saving resulted from this organized effort, it did lead directly or indirectly to the elimination of more than $5,000,000 of waste materials in the first year it was in operation, representing savings reported by only eight of our divisions. Because of the importance of producing more war products and less war scrap, and because it is believed that elements of this program may be of considerable value to other organizations, an outline of its general characteristics will be given:

Contributed by the Management Division and presented at the Fall Meeting, Rochester, N. Y., Oct. 12–14, 1942, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

A PROGRAM OF MATERIAL UTILIZATION

The material-utilization program had its formal inception, after a rather extended discussion of the subject on the part of our executive group, on July 18, 1938, when C. E. Wilson, then executive vice-president of the Corporation, addressed a letter to the general managers of all of our manufacturing divisions. In this letter Mr. Wilson said in part:

> We all know that men in the various Divisions are working on this problem at all times, and some of the Divisions have intensified their efforts to save material in recent months. However, in order to make more rapid progress throughout the whole Corporation and get more concentrated effort on the problem, we are asking the co-operation of all of the Divisions in the following program:
>
> 1 A central committee in Detroit is being appointed. This committee will be available to co-operate in and co-ordinate the activities to reduce our material costs.
>
> 2 Under the supervision of this committee, an exhibit will be prepared in Detroit showing examples of changes in specifications and processing to effect important material savings, and data and information will be collected and made available on what the scrap losses now are on various items. They will also assist in getting information and in circulating it to all of the Divisions to assist them in working out their particular problems.
>
> 3 We are asking the General Manager of each Division for each production plant to appoint a committee of from three to five men from members of their purchasing, inspection, engineering, tool-design, and production organizations. This committee should meet once a week and review the principal items being produced in the particular plant to see if material savings can be made, with the object of covering all the items produced in the plant in about six months.
>
> 4 A record should be made of all important improvements and savings in material made as a result of suggestions from these committees, and where in the opinion of the chairman it is worth while the information should be sent to Detroit so that committees in other plants can be advised where similar problems exist.
>
> 5 We appreciate that many members of the organization have already been working on this problem, which is an old one in industry. We suggest, however, that the various committees review all items with the following points in mind:
>
> (*a*) Can forgings or stampings be substituted for more expensive castings or screw-machine pieces?
>
> (*b*) Can cheaper material be substituted for more expensive material and still obtain the necessary quality and result? For example,



EXAMPLE OF PEACETIME MATERIAL SAVING IN AUTOMOBILE PRODUCTION

(Two miters from Chevrolet, Pontiac, and Olds sedan quarter-panel sheets, flash-welded together to make one back window inner panel. Offal from window opening flash-welded to make sheet for rear-seat cushion support. Saving $62,169 per model year.)

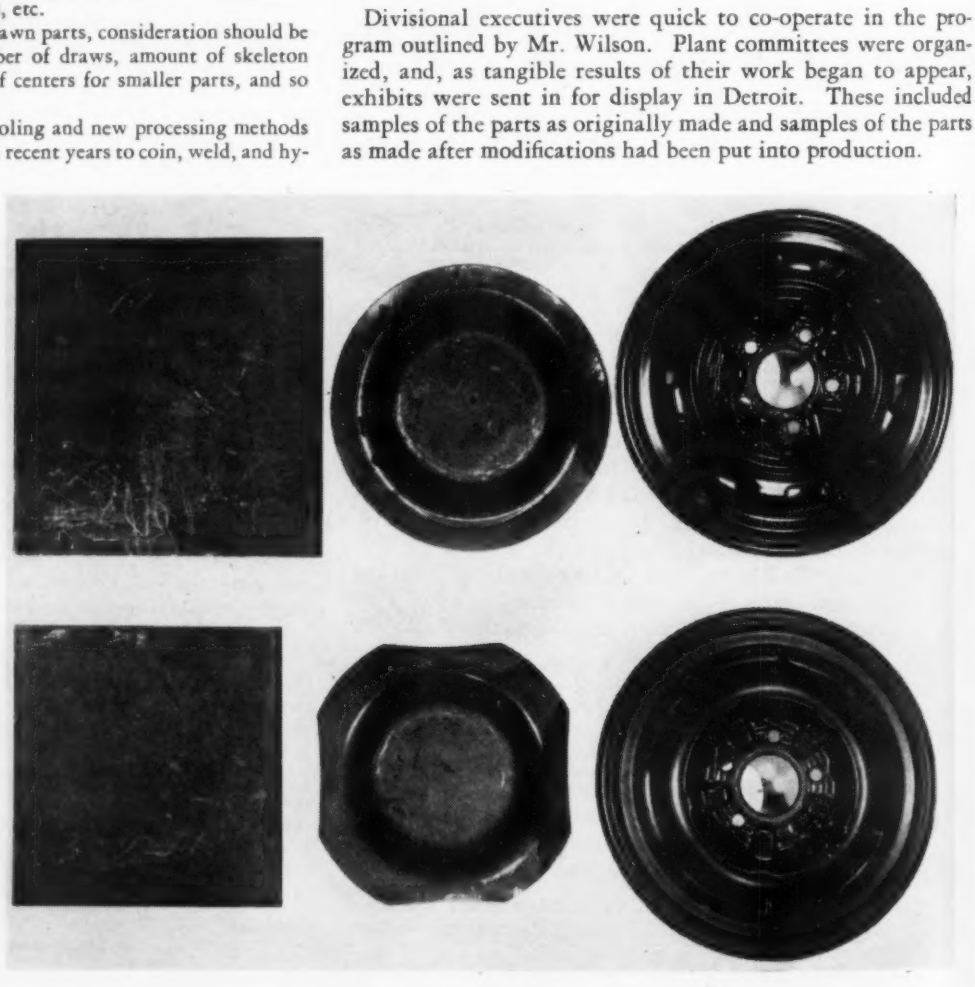
hot-rolled for cold-rolled steel, elimination of extras, standard specifications, etc.

(*c*) Careful study of finish allowance with relation to the number of pieces scrapped, best chucking methods, proper locating points, centering, inspection methods, etc.

(*d*) In considering stamped and drawn parts, consideration should be given to multiple dies, number of draws, amount of skeleton scrap, nesting, possible use of centers for smaller parts, and so forth.

(*e*) Give consideration to new tooling and new processing methods which have been developed in recent years to coin, weld, and hydrogen-braze parts to save machining and material or to make a cheaper assembly of parts to be substituted for more expensive and complicated stampings, castings, forgings, and screw-machine pieces.

Divisional executives were quick to co-operate in the program outlined by Mr. Wilson. Plant committees were organized, and, as tangible results of their work began to appear, exhibits were sent in for display in Detroit. These included samples of the parts as originally made and samples of the parts as made after modifications had been put into production.



CHANGES IN WHEEL DESIGN ACCOMPLISH WORTH-WHILE SAVINGS

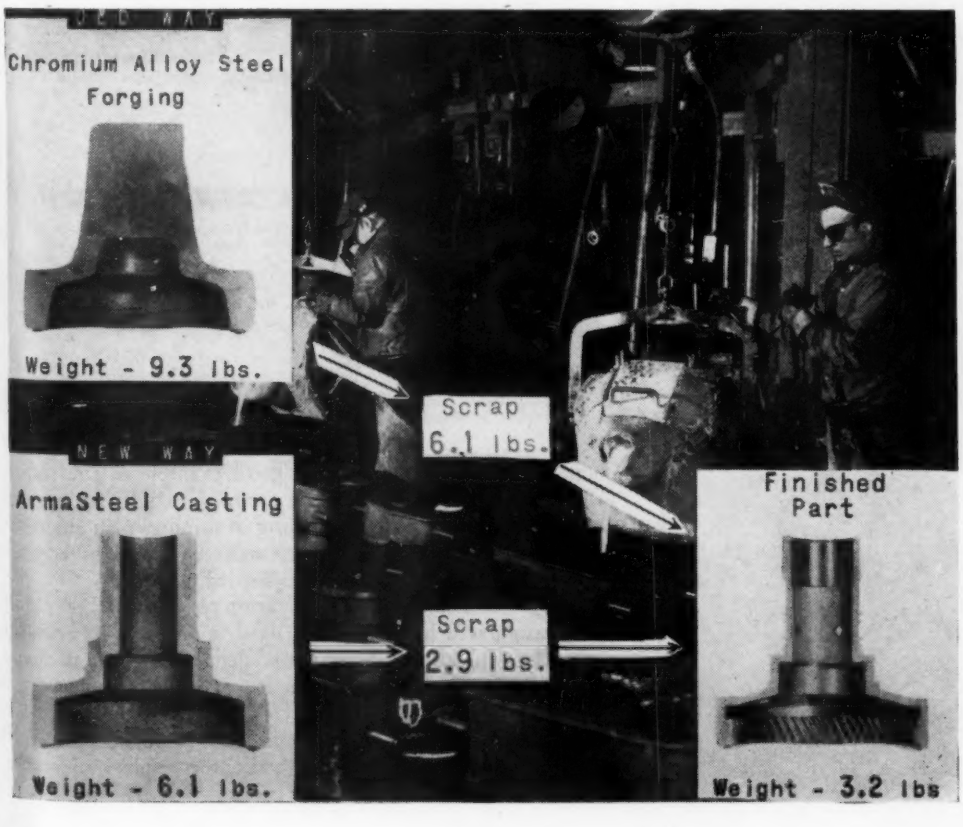
(The 1938 design with riveting flange around entire periphery of disk and 10 stamped ventilation slots required an 11.1-lb blank to form an 8.7-lb disk. The 1939 design, utilizing the corners of a smaller blank for riveting flanges, and segments between corners for ventilation slots, requires an 8-lb blank to form a 7.06-lb disk. Material saving 12 lb per car; material and labor cost saving $0.9305 per car.)

SAVING CRITICAL MATERIALS IN GUN MANUFACTURE

(The finished antiaircraft-gun part held by a worker in the Pontiac Plant of General Motors weighs 6 lb. Formerly it was machined from a 56-lb solid steel forging, which resulted in the 50 lb of scrap shown in the left foreground. Pontiac engineers replaced the forging with a 14-lb piece of steel tubing, welded to a forged base. Now only 8 lb of scrap, shown in the small pile at the right, need be machined away to produce the finished part.)

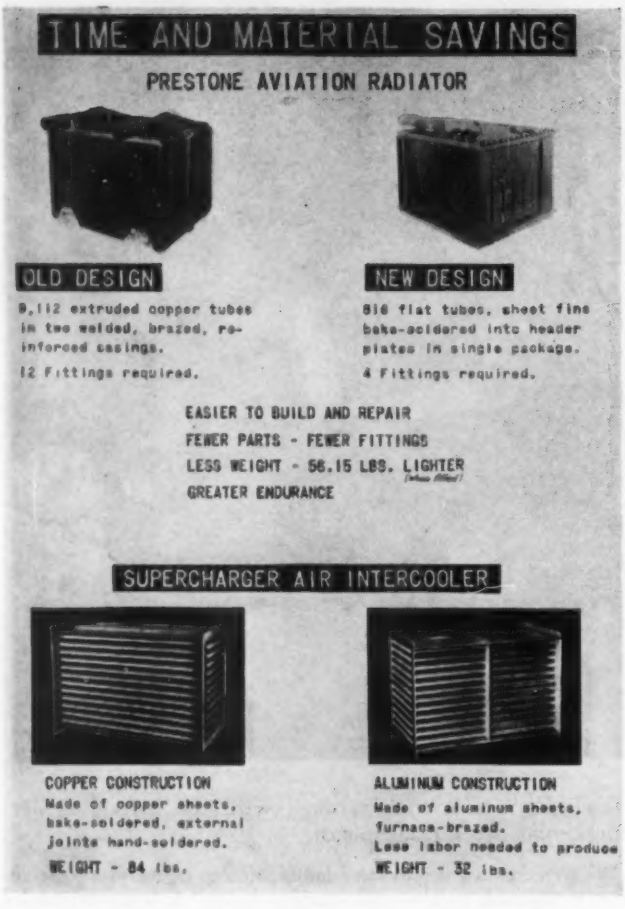
The central committee took the position that the introduction and application of improvements should not be motivated by it, but rather that it should serve in the capacity of a coordinating unit to stimulate divisional activities by following up to see that the plant committees did develop a definite procedure and a scheduled meeting time for carrying out the program. This idea was in keeping with the decentralized plan of operation which the corporation follows. A letter sent out on November 3, 1938, which typifies the approach of the central committee in following through with the individual divisional committees, reads in part:

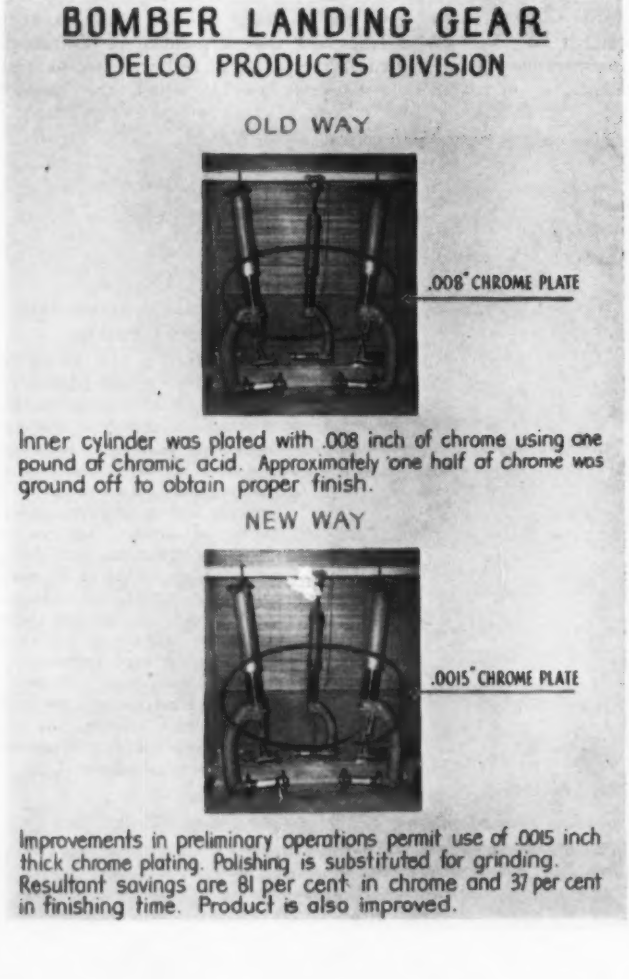
We are attaching hereto some information in regard to a somewhat definite approach to a material-study program. It is not intended to prescribe a definite procedure as this will vary according to the approach of the Committee and also the character of the operation being studied; but, in view of the fact that a number of Committee Chairmen have asked regarding the procedure followed, we have attempted to fit together some orderly way in which this problem



NEW METAL ELIMINATES BOTTLENECKS

(Arma Steel, a new metal developed by General Motors research engineers, can be molded to approximately final shape to replace critical steel forgings, cast steel, and bar stock for tank, gun, engine, and truck parts. It requires less machining and is easier on tools. Illustration shows molten Arma Steel being poured into molds at Saginaw Malleable Iron Division of General Motors. At the left above is a cross section of the solid steel forging used formerly to produce a tank part. Below is the Arma Steel casting now used, also in cross section. At the right in cross section is shown the finished part.)


TIME AND MATERIAL SAVINGS
PRESTONE AVIATION RADIATOR
OLD DESIGN
2,112 extruded copper tubes in two welded, brazed, reinforced casings.
12 Fittings required.
NEW DESIGN
816 flat tubes, sheet fins bake-soldered into header plates in single package.
4 Fittings required.
EASIER TO BUILD AND REPAIR
FEWER PARTS - FEWER FITTINGS
LESS WEIGHT - 56.15 LBS. LIGHTER
GREATER ENDURANCE
SUPERCHARGER AIR INTERCOOLER
COPPER CONSTRUCTION
Made of copper sheets, bake-soldered, external joints hand-soldered.
WEIGHT - 84 lbs.
ALUMINUM CONSTRUCTION
Made of aluminum sheets, furnace-brazed.
Less labor needed to produce
WEIGHT - 32 lbs.

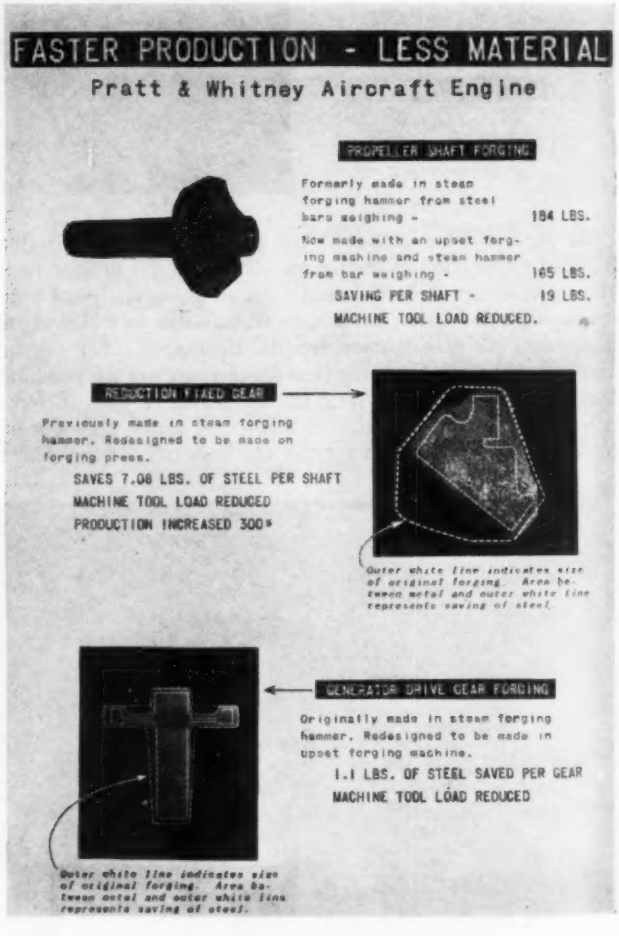

BOMBER LANDING GEAR
DELCO PRODUCTS DIVISION
OLD WAY
.008" CHROME PLATE
Inner cylinder was plated with .008 inch of chrome using one pound of chromic acid. Approximately one half of chrome was ground off to obtain proper finish.
NEW WAY
.0015" CHROME PLATE
Improvements in preliminary operations permit use of .0015 inch thick chrome plating. Polishing is substituted for grinding. Resultant savings are 81 per cent in chrome and 37 per cent in finishing time. Product is also improved.

can be approached in case you have not already started your program.

Where it is felt desirable to study a given group of items, certain Committee Chairmen will be requested to have representatives here for a joint study of such materials. However, we urge that wherever it is convenient you have members of your Committee or your organization visit the exhibit. New items are constantly being added to this exhibit and while they may not be the specific parts that you are interested in, the methods and processes used in the parts submitted may be of substantial help to you in the solution of problems which concern you directly.

In the last analysis, the effective work in material saving must necessarily be done by the individual plant committees, and it is not our thought here either to dictate a program or to attempt to furnish information that may in any way prove embarrassing between Divisions. It is the desire of our Committee, however, to be of service to you in whatever way possible, and we trust that you will call upon us for any help you feel we will be able to give you. In the meantime, please let us have copies of your minutes in order that we can keep a more definite line on the manner in which you are approaching this study.

You will note particularly the final sentence of this letter, in which a request is made for copies of the minutes of divisional


FASTER PRODUCTION - LESS MATERIAL
Pratt & Whitney Aircraft Engine
PROPELLER SHAFT FORGING
Formerly made in steam forging hammer from steel bars weighing - 184 LBS.
Now made with an upset forging machine and steam hammer from bar weighing - 165 LBS.
SAVING PER SHAFT - 19 LBS.
MACHINE TOOL LOAD REDUCED.
REDUCTION FIXED GEAR
Previously made in steam forging hammer. Redesigned to be made on forging press.
SAVES 7.08 LBS. OF STEEL PER SHAFT
MACHINE TOOL LOAD REDUCED
PRODUCTION INCREASED 300%
Outer white line indicates size of original forging. Area between metal and outer white line represents saving of steel.
GENERATOR DRIVE GEAR FORGING
Originally made in steam forging hammer. Redesigned to be made in upset forging machine.
1.1 LBS. OF STEEL SAVED PER GEAR
MACHINE TOOL LOAD REDUCED
Outer white line indicates size of original forging. Area between metal and outer white line represents saving of steel.

committee meetings. This is a good example of the indirect follow-up used to insure that the committees did have meetings at scheduled times. The furnishing of minutes also enabled us to measure the activities of the committees and discover points in which further stimulation was needed.

A very successful material-utilization program had previously been inaugurated by the Buick Division and was in operation at the time the general plan was launched. Because of the excellent results obtained, we used it somewhat as a pattern to indicate to other divisions a procedure which they might well follow. For the same reason it is believed to be well worth outlining. The Buick program had three primary objectives, which were:

1 The substitution of lower-cost materials wherever possible.

2 The modification of design or process to reduce quantity of material used.

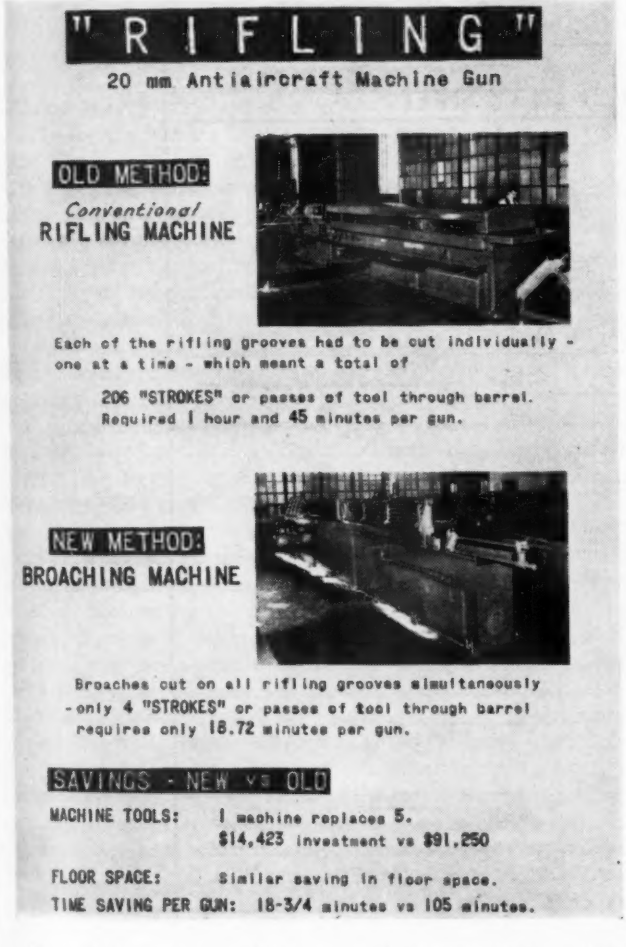
3 The possible further use of material salvaged from certain operations.

This measuring stick was applied to each part of the automobile. As the individual items were taken up they were also studied as to:

(*a*) Cost of the item or material purchased.
(*b*) Material remaining in the part when it was completed.
(*c*) The value of material lost.

The personnel of the Buick committee consisted of the following:

Representative from foundry, forge, or sheet-metal plant as warranted.
Representative of management of factory producing finished part.
Process engineer.
Time-study man.
Representative from car engineering and from Metallurgical Division.
Foremen from all machining departments.

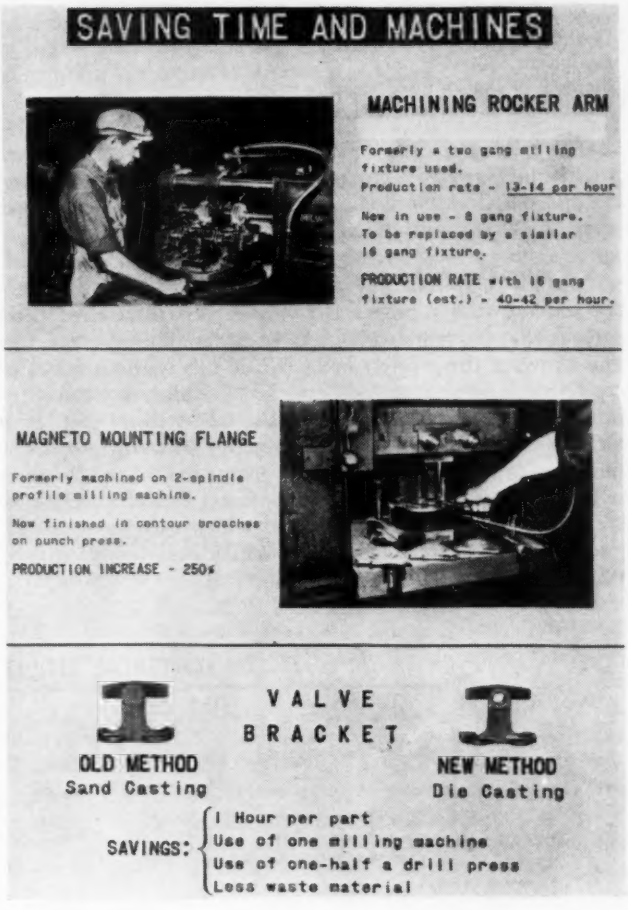

"RIFLING"
20 mm Antiaircraft Machine Gun
OLD METHOD:
Conventional
RIFLING MACHINE
Each of the rifling grooves had to be cut individually - one at a time - which meant a total of
206 "STROKES" or passes of tool through barrel.
Required 1 hour and 45 minutes per gun.
NEW METHOD:
BROACHING MACHINE
Broaches cut on all rifling grooves simultaneously - only 4 "STROKES" or passes of tool through barrel requires only 18.72 minutes per gun.
SAVINGS - NEW vs OLD
MACHINE TOOLS: 1 machine replaces 5.
$14,423 investment vs $91,250
FLOOR SPACE: Similar saving in floor space.
TIME SAVING PER GUN: 18-3/4 minutes vs 105 minutes.

In studying the specific items and in preparation of the samples for investigation, the following points were covered:

Blueprint and material specification.
Rough forging, casting, or stamping.
Part partially machined through each operation to show amount of stock removed, particularly on primary machining operations.
Finished part through each operation.
Finished part ready for assembly.
Labor routing showing production per hour on each operation.

The study itself by the committee included the following points:

Material specifications and size of billet or sheet.
Methods of manufacture.


SAVING TIME AND MACHINES
MACHINING ROCKER ARM
Formerly a two gang milling fixture used.
Production rate - 13-14 per hour
Now in use - 8 gang fixture.
To be replaced by a similar 16 gang fixture.
PRODUCTION RATE with 16 gang fixture (est.) - 40-42 per hour.
MAGNETO MOUNTING FLANGE
Formerly machined on 2-spindle profile milling machine.
Now finished in contour broaches on punch press.
PRODUCTION INCREASE - 250%
VALVE BRACKET
OLD METHOD
Sand Casting
NEW METHOD
Die Casting
SAVINGS:
1 Hour per part
Use of one milling machine
Use of one-half a drill press
Less waste material

TRIGGER COVER PLATE
20 mm. AA machine gun
OLD METHOD
Machined out of solid steel forging weighing 5.37 pounds.
Weight of finished part 1.47 pounds.
NEW METHOD
Two steel stampings riveted together.
Weighs 3.37 pounds.
Weight of finished part 1.47 pounds.
SAVINGS: NEW v. OLD
2 pounds of scrap per piece.
Machine operations cut from 29 to 15.
Machines necessary reduced from 12 to 8.
$20.91 cost reduction.

Amount of stock for finish on forgings and castings.
Design of parts, limits, etc.
Equipment.
Methods of chucking and locating points.
Elimination of operation and equipment.

After arriving at their conclusions, proposals were followed up with the Standard Department to see that within a reasonable time practical proposals were adopted and necessary corresponding changes made in manufacturing information.

IMPLEMENTING A MATERIAL-SAVINGS PROGRAM

In starting such a program it would perhaps be natural to conclude that the first and hardest work should be done on the items showing the greatest loss. While this without doubt is very desirable, the human factor needs to be taken into consideration, for it goes without saying that men will do their best work on an item in which they personally are most interested. Consequently, instead of selecting a list of items from those in the relative cost data showing the greatest loss of material, it may pay to follow through on items which may be suggested by individual department heads on which considerable thinking and planning has already been done but on which no definite action has been taken to bring the saving to adoption.

The Buick organization deemed it desirable in many cases to make its studies by departments, having the foreman of a department sit in at a meeting arranged in his department to suit his convenience. Other plants set up a stated time and place for a meeting where various parts to be studied could be brought in as a collective exhibit. The foreman or other persons interested in the production of the particular parts were asked to attend the meeting.

The committees were advised that suggestions and investigations should be followed up as rapidly as possible to a definite conclusion, either by having the suggestion adopted and incorporated in regular manufacturing information, or by making a definite record of the fact that after reasonable study the suggestion or proposal did not warrant adoption.

Summarizing, it was suggested to the committees that:

1 They establish a definite time or procedure for meetings at stated intervals.

2 They assemble such information as would indicate items most worthy of study, either from the standpoint of losses in-

GM 335
Printed in U.S.A.

MATERIAL UTILIZATION CHECK SHEET

Part Name _____ Part No. _____

Material Specifications _____
State whether forging, casting, bar, sheet, etc.

Sellers Extra _____
State amount and reason

Weight _____ (Rough) _____ (Finished) _____ (Loss) _____ (% Loss)

Production or volume to warrant investigation _____
Sufficient or Insufficient

Referred to _____ By _____ Date _____
Individuals or Departments

		NO	YES	REMARKS Explain in detail attaching supplementary memoranda if space is too limited.
1.	Can the part be eliminated or a standard part substituted by redesign?			
2.	Can the design be simplified or changed to facilitate manufacturing and/or assembly?			
3.	Would another manufacturing method involving redesign be warranted, material and processing cost considered? (Welding, stamping, die casting, etc.)			
4.	Can the gauge, size or weight be reduced?			
5.	Are the limits, tolerances and finishes finer than necessary?			
6.	Can the finish specified be eliminated or a cheaper finish substituted? (Zinc, cadmium, parkerize, etc.)			
7.	Is the material or part unnecessarily clean, smooth, etc., considering function, cost and manufacturing requirements? (Pits, seams, burrs, flash, welds, gates, wires, sharp edges.)			
8.	Can machinability be increased or material cost reduced by substituting another form of material? (hot rolled cold rolled, billet stock, hot form rolled bars, coiled strip or sheet, etc.)			
9.	Are any sellers extras that apply avoidable?			
10.	If manufactured, could item be purchased for less; or vice versa?			
11.	Could improvement of the material be justified by manufacturing advantages? (Uniformity, cleanliness, straightness, smoothness, normality, or anneal, care in handling, etc.)			
12.	Could a change in processing or equipment be justified? (Broaching, milling, bearingizing, honing, cold heading, multiple operations, etc.)			
13.	Can an operation be eliminated, combined with another, or performed during idle time of other operations?			
14.	Would a change in locating points, chucking or sequence of operations be advantageous?			
15.	Is tool or die life unsatisfactory or is machine set-up cost excessive?			
16.	On new work is proposed tooling cost excessive, quality and efficiency considered or is the tooling program over ambitious, volume considered?			
17.	Can finish allowance be reduced? (Trim, bore, grind, etc.)			
18.	Can offal be reduced or utilized?			
19.	Would rescheduling be advantageous? (More or less frequent production)			
20.	Can any inspection operation be reduced or eliminated?			
21.	Could material handling, stocking, etc., be improved? (Between operations, or departments—conveyors, stock boxes, trucks, etc.)			
22.	Could a saving be made in shipping or packing? (Tariff classification, dunnage, demurrage, etc.)			

Additional Suggestions: _____

Submitted by _____ Date _____

volved, or because of the special interest of the individuals concerned.

3 They carry the study forward as rapidly as possible to a conclusion, either by definite adoption or rejection.

As stated previously, the activities of the central committee were primarily limited to following up the activities of the individual divisional committees, at the same time making available through the central office exhibit or through published case studies such items as were of general interest throughout the manufacturing units of the organization. The following is an excerpt from another of these follow-up letters:

> The record of results so far obtained in all divisions definitely establishes the importance of the work and contradicts any idea of a saturation point beyond which lessened returns could be expected. We are personally confident that your future efforts will continue remunerative and that the activity will justifiably become a permanent part of your organization. A few inquiries as to the intended jurisdiction of the Committees and the scope of their program prompts the thought that clarification might be generally helpful. The tentative check sheets, copies of which are attached, illustrate our idea of an unrestricted and all-inclusive material-utilization analysis.

The check sheet proved to be a very important element of our program. For the reader's information, a sample sheet is reproduced.

Another type of follow-up which was used wherever possible was to have a member of the central committee sit in with the plant committees at their periodic sessions. Supplementing the Detroit exhibit, displays were set up by many divisions themselves so that members of their own organizations could observe the materials that were under special study or see the modifications that had been made or were under consideration. The Detroit exhibit itself was an outstanding success, and it was not unusual to have as many as twenty visitors a day. While not large in numbers, such attendance indicated a high degree of interest on the part of engineers and process men in studying the items which were presented.

One of the outstanding displays in the Detroit exhibit was a comparison of connecting rods manufactured by the car divisions. We showed a sample of each successive operation in connecting-rod production from the start to the finish. This exhibit excited considerable interest and developed competition between the divisions in the modification or combination of operations in an effort to reduce the total number of operations in completing the connecting rod. It was found, for example, that one division had been completing a rod in as many as five fewer operations than another division whose rod was very similar in construction. Naturally, the division using more operations immediately launched a study to determine where combinations or reductions could be made. While in this case, the primary purpose was to develop a saving in machining time and operations, because of the nature of the process followed by some of the divisions the comparison also made material losses conspicuous, so that savings were realized in materials as well as in time and equipment.

One principle that we established in connection with the Detroit exhibit was that of continual change. We saw to it that the displays never became museum pieces. There were daily changes in the items on exhibition so that engineers and process men always found something new to study each time they visited Detroit.

Where an unusual amount of interest was shown in a particular part or process, a case study was prepared. Such studies included not only photographs of the part before and after improvement but detailed information on the objectives of the study, the design of the part, its approximate cost, whether patents were involved, and some idea of the saving accomplished in the specific instance where it was applied. In the case of changes which, it was felt, could be rather generally applied in all divisions, slides were made, accumulated in a mailable package and made available to plant managers for use with supervisory groups or in meetings called specifically for the study of improved processing.

It may seem to some that a program of this kind is only applicable to a large organization. This is far from the fact. Any plant can organize a material-study committee and the procedure which was used in the case of each of our plant or divisional activities can be followed with equal effectiveness.

The pay-off for a program of this kind necessarily comes in tangible results, and in our own case it is worthy of note that in the first year of our effort, as previously stated, eight of our principal divisions reported a saving equivalent to a 10 per cent reduction in the total raw-material requirements of these divisions.

The foregoing recital of a peacetime program has been given to demonstrate that the program was not a theoretical one. It was given practical application in the development of an organized effort which was most effective in its resulting savings of material.

TRANSLATING THE PROGRAM TO WAR-MATERIAL SAVINGS

Turning now to the war period, it would be claiming too much to say that all of the material savings effected to date on war products are the direct result of this program. The matter of material utilization, material saving, and reduced processing for the conservation of much-needed machine-tool equipment has become more or less of a mania with us. In addition to the individual efforts of our various plants, we have an organized approach in Donald M. Nelson's program to give consideration to valuable suggestions made on the part of employees and to publish these suggestions for general use throughout the industry. We have gone a step further and are awarding war bonds and stamps for acceptable employee suggestions.

Many publications dealing with mechanical arts and supervision have been devoting much of their space to promoting progress in the saving of materials, the saving of labor, and the conservation of valuable machine-tool equipment. The magazine *Wings*, published by McGraw-Hill through an arrangement with the Army and Navy Personnel Divisions, is made available at no cost to supervision of organizations holding aeronautical contracts and consists largely of descriptions of developments in such plants which have been contributory to better manufacturing processes and material savings. The Ordnance Division has sponsored the publication of *Tremendous Trifles*, which also shows what can be done in the saving of vital materials by substitution and modification in design and process.

For more specific information, the illustrations accompanying this presentation show a limited number of case examples of what we have accomplished along the lines of material savings, both in commercial manufacture during the operation of our material-utilization program, and in our war production since we stopped making automobiles.

CONCLUSION

It should be emphasized that on the problem of material saving the best results are obtained by organized effort. There are at the moment three limitations to our war effort; (1) the available manpower, the taxing of which is already running our plants into day-to-day overtime; (2) the limitations on productive capacity, because of the shortage of machine tools, total relief for which is not in sight for a considerable period; (3) the limited supply of critical materials, which has put a definite ceiling on the volume production of many of our important materials.

Whatever is done in the way of reducing scrap, either by improved design or reduction in the base-material requirement, both of which result in a saving in man-hours and in machine-tool-hours, is making a constructive contribution in extending physical support to our armed forces in the field.

Official OWI Photo by Hollem

GLASS GAGES OF VARIOUS TYPES ARE REPLACING STEEL GAGES AT FRANKFORD ARSENAL

(Left, top to bottom: double-end plug gage, "Go" plug gage, ring gage. Right, top to bottom: "Not Go" plug gage, double-end solid-handle plug gage, double-end taper-lock standard-handle plug gage.)

GLASS *for* PRECISION GAGES

Developments of Ordnance Department and Glass Manufacturers Introduce New Material to Replace Steel

By COL. H. B. HAMBLETON

CHIEF OF GAGE SECTION, U. S. ORDNANCE DEPARTMENT, WASHINGTON, D. C.

IN AN effort to contribute to the program for the conservation of steel, the Ordnance Department has initiated a development project of glass gages. The responsibility for the development project has been assigned to Frankford Arsenal. This arsenal, with the aid of the most progressive glass manufacturers in the country, has formulated tentative specifications and provisional standard drawings of glass gages. These standards, in so far as is possible, will be dimensionally the same as those of the American gage design standard, shown in publication CS8-43 of the National Bureau of Standards. This standardization of steel-gage design was formulated and completed prior to this war, and has insured complete co-ordination and interchangeability of all steel gages manufactured.

Up to this time, Frankford Arsenal has procured from the Corning Glass Works, Corning, N. Y.; Fischer and Porter Company, Hatborough, Penn.; The A. H. Heisey Company, Newark, Ohio; T. C. Wheaton Company, Millville, N. J.; Specialty Glass Company, Newfield, N. J.; and The Blue Ridge Glass Corporation, Kingsport, Tenn., a limited number of glass gages for experimental and development purposes. One of these gages, similar to the sample displayed, had been used in the Frankford Arsenal cartridge-case shop for the inspection of 57-mm cartridge cases. This gage performed 260,000 gaging operations before it was worn out. For the first 160,000 operations, the wear was only 0.00005 in. A steel gage for this same duty normally has a life of 60 to 70 thousand operations. The Ordnance Department now has several glass gages under test on brass gears for mechanical time fuzes, steel parts for other fuzes, and cartridge-case inspection previously referred to. The results to date indicate that glass gages are giving a very satisfactory performance and, in some cases, show very definite advantages over steel gages, some of which are as follows:

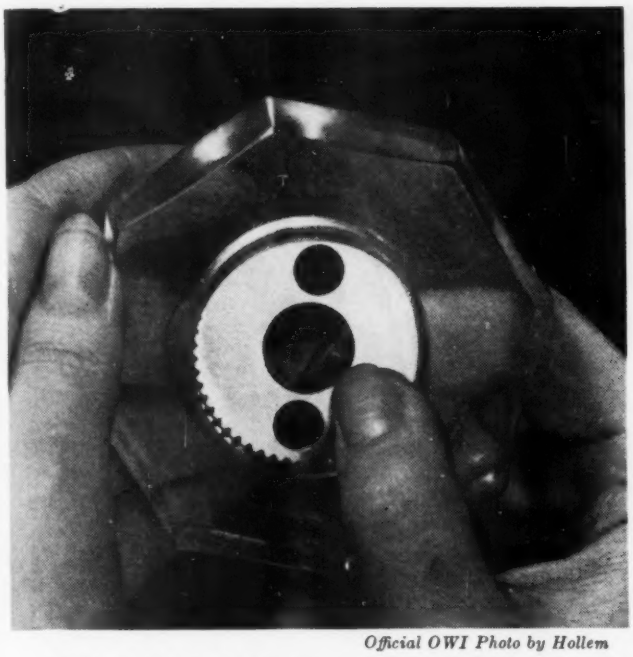
(1) Many greasings and degreasings are eliminated, since no question of rust is involved.

(2) Glass gages are much easier in handling inasmuch as they are lighter than steel.

(3) Glass gages afford visibility in inspection which is not always possible with steel.

(4) Glass will more or less teach the inspectors to have respect for handling gages.

Presented at meeting, New York, N. Y., March 9, 1942, of the Metropolitan Section, The American Society of Mechanical Engineers.



Official OWI Photo by Hollem

BRASS GEAR PART GAGED BY PLAIN RING GAGE OF GLASS

(5) Most important at this time is the saving of tool steel for other uses.

(6) Perspiration on the hands of the inspectors has no corrosive effect on the glass gage as it does on steel.

(7) When the component is very near the size of the gage, there is less tendency for the component to seize or gall in or on the gage.

(8) Scratches on glass do not raise burrs or change the effective size of the gage.

(9) The thermal conductivity of glass is less than steel, and therefore heat transferred from the hands of the inspectors to the gage will not affect the gaging dimensions.

(10) Glass appears to have abrasive-resisting qualities equal to or better than steel in many gaging applications.

(11) The comparative weights of glass and steel are around 160 and 485 lb per cu ft, respectively. The lighter weight of glass is obviously an advantage in the use of gages.

The old adage that "there is nothing new under the sun" also applies to the subject of this talk. The Ordnance Department did not discover glass gages; we merely believed in their possibilities and, after extensive investigation, really put considerable effort behind their development, with the result that we believe that at least 50 per cent of the standard steel gages can be replaced by glass with the assurance that the standards of inspection will not only be maintained but, in some cases, a greater degree of accuracy may be possible.

Early in July, 1942, while investigating a multi-type gage at Delco Rhemy Division of General Motors Corporation in Kokomo, Ind., an officer and the chief engineer from the Philadelphia gage suboffice had their attention called to a glass gage. Upon investigation, we discovered that The A. H. Heisey Company, of Newark, Ohio, had been producing a few gages experimentally. After considerable discussion an experimental order was placed to determine the value of glass for this type of ordnance activity.

About this same time the Corning Glass Works, of Corning, N. Y., and the T. C. Wheaton Company, of Millville, N. J., were solicited and requested to give the Ordnance Department the benefit of their long experience in glass technique. These two outstanding glass producers have given us their wholehearted co-operation.

In view of the many requests for additional information on the grinding of glass plug and ring gages, the T. C. Wheaton Company has decided to publish a weekly paper giving the results of tests and experience gained from the previous week. They inform me that the response to the original paper on glass gage blanks was more than gratifying. On Feb. 5, 1943, I called a joint meeting of the glass manufacturers, gage manufacturers, and grinding-wheel representatives for the purpose of discussing tentative standards and specifications for glass gages. In the design of standard blanks, great care has been taken to parallel the American gage design standard, in order that handles will be interchangeable and the possible resistance to the use of glass gages will be minimized. The main deviation from steel is a radius which is required on glass gages to keep them from chipping. Mr. Wheaton informs me that the standard gage makers are giving him the best possible co-operation, and he in turn, with his weekly bulletin, is informing them of the technique of glass gage grinding as compiled from his own experience and that of gage makers to whom he has furnished blanks.

Contrary to common thought it is not believed that much change will be required, if any, in the standard machines for grinding glass plug gages. There has been a great deal of discussion regarding possible changes required in the standard grinders for steel, when grinding glass blanks. This, I believe, can now be discounted. The Wheaton Company has used a Norton 6-in. × 18-in. type C, having a wheel speed of approximately 1190 rpm, using a 20-in. × 1-in. × 12-in. wheel with approximately 6000 surface feet per minute, which we understand is a common speed for most cylindrical grinders. By using silicon-carbide wheels of 60–80 grit, they were able to rough to within 0.003–0.004 in. of finish size in a short time. They recommend a rather fast table traverse speed in this operation with a slow work speed.

After changing to a 180-grit silicon-carbide wheel using very slow table traverse speed and a slow work speed, they were able to obtain a beautiful finish on the surface. The blank used was approximately 1 in. in diameter.

It is interesting to note that during the last four or five passes of the wheel, without changing the wheel setting, they

Official OWI Photo

THIS GAGE CHECKED 160,000 CASES WITHOUT WEAR

(Presumed life of a steel gage is 50,000 cases.)

turned off the coolant and secured a polished surface. In regard to the coolant required for grinding glass, they have found from experience that plain water is all that is required. However, it is necessary to provide some agent to prevent rust on the machine; for this, they have used International Chemical Company's No. 219 oil, diluted 25 to 1.

In using the taper lock handle, it will not be necessary to grind the taper on the glass shank as this can be molded close enough to give the required fit.

It is entirely possible to grind centers in the ends of plugs, using a tungsten-carbide drill and lapping with a center lapping stick, such as a Norton 60 Q $1/2 \times 2$. Blanks will be supplied by glassmakers with the centers ground in. The question has been asked many times, whether the molded male centers could be supplied on the blank; this is impractical to do in glass molding procedure.

Official OWI Photo by Palmer

STEEL PLUG GAGE COMPARED WITH GLASS PLUG GAGE WHICH REPLACES IT AT FRANKFORD ARSENAL
(A plain ring glass gage shows in the foreground.)

With your permission, I would like to digress from the subject of glass gages and outline briefly the Ordnance gage program.

Early in August, 1940, it became evident that the peacetime capacity of the gage industry, which is normally about $3\frac{1}{2}$ to 4 million dollars, was apparently insufficient to meet the visualized load of the projected munitions program, taking into consideration Ordnance, Air Corps, and Navy requirements. The problem was presented during the summer of 1940, approximately one year and three months before Pearl Harbor, to the office of the Assistant Secretary of War, who is charged with industrial planning. Mr. Mason Britton, who was the chief of the Tool Section of the Advisory Commission, Council of National Defense, which office later became the War Production Board, took this problem under advisement.

From surveys made in September, 1940, the first general gage-expansion program was initiated and approved by President Roosevelt, Oct. 15, 1940, to the extent of four million dollars for increased gage-making facilities. This has been followed by four other expansion programs; the total resulting in the expansion of over 100 gage-making plants at a cost of approximately twenty million dollars. It is estimated that these facility expansions with other normal expansions will have increased the gage-making capacity of the country from four million dollars in 1940 to approximately 125 millions at present.

From this short résumé of the gage facilities expansion program, it must be quite evident to you that the Ordnance Department has been closely following the trend of gage requirements and providing new sources of supply as fast as the demand presented itself.

This balance of supply and demand has been accomplished by studying production programs in advance and increasing gage facilities far enough ahead of the programs to meet the objective. A definite policy of design, distribution, surveillance, and procurement was set up before this war, and with the co-operation of industry the Ordnance Department has been able to carry out its gage program objective.

The Ordnance Department has developed a gaging policy which many agree is superior to most other policies because it recognizes the vital importance of wear allowance and combines wear allowance with gage-makers tolerances, both allocated entirely within the work tolerance zone. This allocation is graphically as well as dimensionally described on an Ordnance chart which appeared in *Iron Age*, Sept. 3, 1942, issue.

Nineteen Ordnance gage laboratories were established at manufacturing arsenals and in Ordnance procurement districts before this emergency. Those in the districts were located in universities for the purpose of training personnel in this highly specialized work. The foresight of the Ordnance Department in equipping these laboratories in the years prior to the emergency can be visualized when one considers the serious bottleneck which developed shortly after the beginning of this war in the supply of precision measuring equipment, which resulted from the restriction of foreign sources of supply and the longer period required to manufacture this type of equipment.

The district laboratories are responsible for constant gage surveillance to detect worn or damaged gages being used by Ordnance inspectors.

The Ordnance Department is constantly striving to improve gaging methods, particularly with the view of obtaining faster inspection. During this emergency many new types of gages have been developed, including multiple-purpose gages employing electrical means for amplification, precisionaire gages for measuring gun bores, special dial indicators for the same purpose, and optical projectors for measuring irregular parts. The development of high-speed multiple purpose gages has been timely because of the difficulty encountered in employing sufficient inspection personnel.

In concluding this talk, may I say that the Ordnance Department is greatly indebted to engineers in industry for their fine co-operation, without which it would have been impossible for us to meet the objective of this enormous program.

RECENT PUBLICATIONS *on* STATISTICAL METHODS[1]

By HAROLD A. FREEMAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN THE last few years, quite a few books of interest to industrial statisticians have appeared. There have also been a number of shorter studies concerned chiefly with quality-control charts. Many of these publications have already been brought to the attention of the readers of this journal and the present review is therefore confined to several important shorter works which are not easily included in these.

The first is a brief publication of Dr. Abraham Wald on statistical inference (8).[2] Among the literature of modern statistical theory there is as yet no treatise and only one systematic advanced textbook, the latter being, at the moment, out of print. Wald's survey is therefore especially useful. It gives the reader a broad view of modern statistical theory or at least of (*a*) certain theories of estimating parameters and (*b*) the Neyman-Pearson theory of testing hypotheses, together with asymptotic results, for both theories, obtained in recent years by Wald. It should be said that in his discussion of estimation, the author is principally concerned with Neyman's method of confidence intervals; the systems of estimation associated with the names of Bayes, Fisher, and Markoff are briefly noted.

These subjects may appear to be remote from the immediate interests of industrial statisticians but this is hardly the case. In many problems—for example, in inspection—a statistician must often estimate parameters from the samples at hand and even more often he must be able to find good ways of testing a certain hypothesis. The fact that "best" tests may not always be available for the complex hypotheses with which an industrial statistician deals does not reduce the practical utility of these researches. Wald's survey, which is admirably organized and clearly illustrated by simple examples, should be read by all industrial statisticians who wish to get a better view of the foundations of their field.

Dr. R. A. Fisher's brochure on estimation (2) is primarily an exposition—on a mathematical level slightly more difficult than that of Wald's publication—of some of his own contributions to the theory of estimation. In the earlier part, however, Fisher describes and effectively illustrates the three principal methods—mathematical induction, geometry, and characteristic functions—by which the sampling behavior of statistics can be determined. The main body of the study deals with certain properties of maximum likelihood estimates. Illustrations are simple and the difficulties sometimes encountered in practice with multiparameter maximum likelihood equations are not encountered here. Apart from a section on the distinction between Bayes' method and maximum likelihood, Fisher does not here discuss the foundations of likelihood. But a number of important properties of likelihood estimates are given and these, perhaps, more clearly than in Fisher's many original papers.

The application of statistical methods to inspection has been advanced by the work of Dodge and Romig of the Bell Telephone Laboratories (1). They have provided the extensive tables needed to facilitate the use of double sampling in inspection routines. The merits of these tables have been recently described in this journal. Double sampling leads to four unknowns (the two sample sizes and the two acceptance numbers) and the lack of sufficient equations to effect a unique and a relatively easy solution makes it necessary to assign fixed parts of the over-all consumer's risk to each sample. The authors have been able to split this risk with but slight loss in generality and accuracy. The labor of numerical calculation of these tables is heavy so that, while in the case of single samples, sample size and acceptance number can be fairly readily obtained from a single chart for all risks, tolerance, and process fraction defectives, double sampling requires extensive tables to cover the larger number of parameters and tables are accordingly provided only for a consumer's risk of 10 per cent.

Romig (7) has provided the corresponding analysis for a continuous variable.

The usefulness to industrial statisticians of the statistical theory of runs is considerable. We may desire to test for lack of randomness in a series, without specifying the nature of the suspected nonrandomness. Or partial specification may be made. The theory of runs has been adequately stated by Mood (5) and a variety of statistics which can be used for the purpose of testing nonrandomness have been proposed by, among others, Young (9), Kermack and McKendrick, (4) and von Neumann and his associates (6). Certain tests are inefficient in the sense that information contained in the sample at hand is not employed (for example, only the order and not the magnitude of the elements of the series may be used); furthermore, just which of these tests is best in the sense of Neyman-Pearson is not yet known.

The use of the powerful method of characteristic functions to obtain sampling distributions has been noted. In a recent expository article Kenney (3) has provided students of statistical theory with a fine introduction to this method. Distribution theory plays an important role in applied statistics and Kenney's publication will help industrial statisticians, who regularly use the results of distribution theory, toward an understanding of the principal method by which such results are obtained.

BIBLIOGRAPHY

1 "Single Sampling and Double Sampling Inspection Tables," by H. F. Dodge and H. G. Romig, *Bell System Technical Journal*, January, 1941.

2 "Statistical Theory of Estimation," Calcutta University Readership Lectures, by R. A. Fisher, University of Calcutta, 1938. Obtainable through Longmans, Green & Co., New York, N. Y.

3 "Characteristic Functions in Statistics," by J. F. Kenney, *National Mathematics Magazine*, vol. 17, nos. 2 and 3, 1942.

4 "Some Distributions Associated With a Randomly Arranged Set of Numbers," by W. O. Kermack and A. G. McKendrick, Proceedings of the Royal Society of Edinburgh, vol. 57, 1937.

5 "The Distribution Theory of Runs," by A. M. Mood, *Annals of Mathematical Statistics*, December, 1940.

6 "The Mean Square Successive Difference," by J. von Neumann, R. H. Kent, H. R. Bellinson, and B. I. Hart, *Annals of Mathematical Statistics*, June, 1941. Also later papers by von Neumann and others.

7 "Allowable Average in Sampling Inspection," by Harry G. Romig, doctoral thesis, Columbia University, March, 1939.

8 "On the Principles of Statistical Inference," by Abraham Wald, Notre Dame Mathematical Lectures Number 1, Notre Dame, Ind., 1942.

9 "On Randomness in Ordered Sequences," by L. C. Young, *Annals of Mathematical Statistics*, September, 1941.

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] Numbers in parentheses refer to Bibliography.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Mixtures of Oil and Coal in Boiler Furnaces

COMMENT BY JOHN BLIZARD[1]

The paper[2] gives a good summary of the all too meager information on the preparation and combustion of mixtures of fuel and oil. In fact were a plant to be established for the preparation of this fuel, it does not seem that a reasonable estimate of the size, initial cost, and cost of operation of the plant could be made without first carrying out some experiments with a pilot plant.

The author states that the shortage of fuel oil on the eastern coast tends to remove economic considerations as a major factor, and any method that will extend the supplies will be helpful. Nevertheless, this does not mean that one can consider the preparation and distribution of coal-oil mixtures without first endeavoring to estimate whether it would not be better to use other methods for reducing the consumption of fuel oil in the East.

The proposed scheme suggests that approximately 70 lb of oil and 40 lb of coal be used to take the place of 100 lb of oil. It may accordingly be more desirable and practical to continue burning oil in seven out of ten plants and to burn coal by hand from stokers or in pulverized form in the remaining plants. Certainly this latter plan would be subject to very much less uncertainty than embarking upon a scheme which apparently involves extremely fine grinding of coal and correspondingly unduly large pulverizing capacity per ton, uncertain means of mixing the coal and oil, and presumably a change in the oil-burner equipment, coupled with difficulties in dealing with the ash in boilers and furnaces designed for the combustion of oil only.

COMMENT BY ALFRED BUTCHER[3]

At the request of the author and with the co-operation of the officials of the Gulf Oil Corporation, a small test plant was assembled for the preparation and burning of oil-coal fuel, in the boiler plant of the Gulf Oil Corporation's Pittsburgh refinery.

One of the boilers selected was equipped to burn pulverized coal or coke, gas, and oil, either fuel singly or in combination. The other or companion boiler was equipped only to burn gas, oil, and oil-coal fuel. The boilers were Walsh & Weidner cross drum of the sinuous-header type, fired from the drum end using combination horizontal and inclined baffles, size 3250 sq ft heating surface. The combustion chambers are refractory on the floor, sides, and ends; the roof 18-ft × 4-in. boiler tubes having a volume of 1280 cu ft. Two steam-atomizing natural-draft burners of "Gulf" design were used for the gas-and-oil-burning boiler. The preparation plant was designed with the knowledge that no new material was obtainable, due to priorities, time of procurement, etc. Therefore, a makeshift arrangement had to be put together from scrap, second-hand material, borrowed equipment, etc. The plant essentially comprises:

(*a*) A vertical cylindrical tank 4 ft diam, 9 ft high, closed at the top with the exception of a 4-in. pipe downcomer to within 4 in. of the bottom.

(*b*) A 21-in. square open-top vent stack 8 ft 6 in. high was located on the top of the tank, the vent stack being equipped with seven cascading baffles 21 in. × 10 in. of $^1/_8$-in. iron plates set horizontally on 12-in. centers.

(*c*) A 100-gpm 110-ft-head centrifugal pump, driven by a $7^1/_2$ hp motor at a speed of 3500 rpm was used for oil circulation through a 2-in. pipe system (using long-sweep bends); the pump taking oil from the bottom of the tank and discharging it over the cascading baffles in the top of the vent stack.

(*d*) A 4-in. coal-air pipe connection was made from the exhauster of the adjacent boiler pulverized-coal system into the base of the vent stack.

The general idea was to have the coal-oil system charged with coal, by "stealing" the dust with the carrier air from the pulverized-coal mill of the adjacent boiler. The air, being a necessary evil, had to be disposed of; hence the reason for the vent stack on the tank. The cascading oil in descending the stack over the baffles was used to wash out the coal from the ascending air stream. In this regard, the efficiency was low, a considerable amount of very fine coal passing to waste with the released air which had an upward velocity of approximately 200 fpm. Remember, the system had to be built with whatever equipment was available, the vent-stack height to suit the head available of the pump on hand, the design in general had to be distorted to fit one item against another.

By the circulation only of the oil in the system, none being burned or charged to the system, the coal dust accumulated at an average rate of 32 lb per hr, approximating a weight increase of 1 per cent per hour, the system itself is charged with 400 gal of the original heavy fuel oil. A faster rate of coal-dust accumulation was not permissible, or advisable. The test could not interfere with the operation of the boiler from which coal system the dust was being taken with its carrier air, and the dust nuisance from the vent stack had to be looked upon as a fire or explosive hazard. The circulating system appeared satisfactory; no heaters were employed. Batches of 400 gal of the coal-oil mixtures were made and burned. Circulation was not stopped, only when the batch was used up by burning and the system reloaded with fresh oil. The coal-oil mixtures were kept at a fairly constant temperature of 170 F by the pulverized-coal carrier air from the exhauster of the adjacent pulverized-coal mill.

The coal-oil mixtures prepared were sufficient to operate the boiler at a rating of 140 per cent for three hours and allow time to inspect certain parts of the system, flexible tubing to, and the atomizing chambers of, the burners themselves, etc. The pump pressure remained constant throughout the test, irrespective of the percentage of the mix. The quantities flowing no doubt varied as the weight of mix varied; no measurements of flow were taken. At the conclusion of the tests, the tank was opened up for inspection, which showed small accumulations of packed coal dust in places where no oil movement was possible, such as the tank bottom farthest from the pump suction and on the bottom of the flanged section of the manhole opening in the tank.

The fuel characteristics are given in Table 1 as a matter of record.

In order to determine rapidly the approximate quantities of coal by weight in a given coal-oil mix for field information and study, it was deemed advisable to resort to the centrifuge method, that the

[1] Consulting Engineer, Foster Wheeler Corporation, New York, N. Y. Mem. A.S.M.E.

[2] "Use of Mixtures of Oil and Coal in Boiler Furnaces," by W. C. Schroeder, MECHANICAL ENGINEERING, November, 1942, pp. 793–798 and p. 804.

[3] Steam Engineer, Gulf Oil Corporation, Pittsburgh, Pa. Mem. A.S.M.E.

TABLE 1 FUEL CHARACTERISTICS

Fuel Oil

Heavy fuel oil	500 vis
A.P.I. gravity	11.7
S.U. viscosity, 100 F, sec	461
S.U. viscosity, 210 F, sec	53
Flash C.C.	255 F
Flash O.C.	280 F
Fire	335 F
B.S., per cent	0.1

(Analysis and Btu not taken; assumed 18,500 Btu per lb)

Pittsburgh Coal

Moisture, per cent	4.8
Volatile matter, per cent	36.0
Fixed carbon, per cent	53.8
Ash, per cent	10.2
Btu, dry per lb	13440
Sulphur, per cent	1.7
Grindability	63
Ash fusion	2460 F

Coal Dust

Per cent through 50 mesh	99.2
Per cent through 100 mesh	96.0
Per cent through 200 mesh	76.0
Per cent through 325 mesh	58.8

per cent volume by the centrifuge as sediment would correspond to a known weight basis. It was found that at the normal operating temperatures of 170 F:

30 per cent sediment by centrifuge would correspond to approximately 15 per cent coal and 85 per cent oil by weight of mixture.

68 per cent sediment by centrifuge corresponded to 33.3 per cent coal and 66.7 per cent oil by weight of the mixture.

Therefore, for all practical purposes, it could be said that by dividing the centrifuge readings by 2 the percentage of coal by weight in the mix could be determined.

As to the unit weight of a given mixture, the coal used if conceived as an incompressible solid would weigh 89.46 lb per cu ft at 170 F, the oil weighing 58.87 lb per cu ft at 170 F, or a 50-50 per cent mix by weight, 74.165 lb per cu ft or 9.915 lb per gal.

Relative to the changes in viscosity by adding coal dust, Table 2 might be of interest.

TABLE 2 CHANGES IN VISCOSITY OF COAL-OIL MIXTURES AT 170 F

Coal, per cent	Oil, per cent	Viscosity, sec
0	100	81
10	90	92
20	80	112
30	70	150
40	60	260
50	50	1600

Relative to flash and fire temperatures with different mixtures, the experiment indicated practically no change.

The fuel-circulating system, as previously explained, was continuous from the tank to the pump, thence to the open vent stack, the two burners merely being tapped to draw from the system. The quantity of oil burned from the system approximated two gallons per minute; the circulating rate was estimated at 80 gpm. To what amount the circulating rate could have been reduced is not known; as explained previously, no measurement of the circulating rates was determined. The burners did not clog up or appear in any way to act differently from those of straight oil burning up to and including coal-oil mixtures of 43 per cent coal 57 per cent oil by weight, and no additional atomizing steam was required, despite the changing viscosities of fuel under the different coal-oil mixtures.

The burning of the fuel itself was quite satisfactory up to and including 43 per cent coal by weight. As a matter of fact, the fires appeared to be identical, irrespective of the mixtures. Minute "stars" or "sparks" were visible which is to be expected but their travel and life in the furnace were very short. The flame travel of the mixture did not exceed 5 ft from the burner tips.

For record purposes, the furnace draft characteristics are noted in Table 3, when the boiler was operating at 130 per cent rating using 43 per cent coal by weight.

TABLE 3 FURNACE DRAFT CHARACTERISTICS

Furnace draft, in. water	0.10
Uptake draft, in. water	0.14
CO_2 in uptake, per cent	13.0
O_2 in uptake, per cent	6.1
CO in uptake, per cent	0.0
Exit gas temperature, F	510
Steam pressure on burners, psi	90
Fuel pressure on burners, psi	45
Calculated heat release per cu ft combustion volume	15867
Clear fires and stack. The total angle of flame approximately 100 deg with a length of 5 ft	

The products of combustion as viewed through doors at the end of the furnace showed them to be somewhat "dusty." There was little chance for carbon particles to pass away unburned. The soot cleaners cleared the boiler passes satisfactorily; no ash seemed to accumulate. The products of combustion from the boiler were clear at all times.

The tests were conducted between the dates, July 22–August 14, 1942, commencing at low coal rates, increasing to and terminating at 43 per cent coal, 57 per cent oil by weight. Indications appeared that the coal rates could have been higher. The tests terminated because of the need for the observers on other important work.

CONCLUSIONS DRAWN FROM TEST AND FROM SUBJECT MATTER IN GENERAL

1 Apparently 45 per cent coal and 55 per cent oil by weight is a practical combination from a burning standpoint. Beyond this, doubtless the viscosity would reach beyond the practical limits of pumping.

2 It is doubtful whether the commercial value beyond 45 per cent coal will warrant its use, considering the complications which might be involved. A 45 per cent coal mixture represents a 37 per cent reduction of fuel oil used for a given heat release.

3 It is believed that an ordinary pulverized-coal mill used for direct-firing steam boilers with proper classification of fines, whereby 100 per cent will pass through a 100-mesh Tyler screen, is sufficient for practical application.

4 Steam burners for atomization of the fuel are necessary and of advantage. Straight mechanical burners should be looked upon with doubt.

5 The coal-oil mixtures should be kept in motion; the storage tank must be designed, baffled, or equipped with agitators so that no lodgment of the coal dust can take place within it. The mixtures must be circulated in the pipe system, using long-radius bends for turns. Double pipe coils of the ammonia-condenser type can be used for heating the mixture. Steam can be supplied for heating, admitting it between the double pipes.

6 The passes of boilers should be kept free from ash by soot cleaners, etc The furnaces must be designed for the fuel, or means provided for removing the ash accumulation as in the case of a pulverized-coal installation.

7 As to stabilizers, it is cheaper to keep the oil in motion than to use a stabilizer which, as it passes through the boilers, may choke up the flue area itself or cause stoppage by building up solids, due to its chemical reaction with other products.

8 The burners must be tapped directly from the circulating system using proper nonclogging regulating valves for fuel-quantity adjustment.

9 It is believed that wet coal dust mixed with oil should be tested; it may act as an excellent stabilizer. Settling tests should also be made with minimum circulating rates established. Coal of such fineness that all will pass through 150-mesh Tyler screen should be tested. In all probability this will produce a mixture approaching a 100 per cent colloid.

10 The problem of adding dust to the coal is more important than the engineering of mixing, pumping, and burning the mixture. Studies of this should be made without delay.

11 Other and varied tests on a large-scale long-time basis should be made and compared with the results of this experiment.

COMMENT BY A. C. FIELDNER[4]

In order to meet a possible future shortage of fuel oil in the United States, the Bureau of Mines has given consideration to the possibility of making oils from coal by a modification of the Bergius I. G. hydrogenation process. Investigations now in progress at the Central Experiment Station of the Bureau of Mines at Pittsburgh have shown that it is possible to convert bituminous coal to a Bunker C type of heavy fuel oil by mild hydrogenation at pressures of approximately 1000 psi.

In Europe, the Bergius process is used for producing gasoline from coal. A paste of equal parts of pulverized coal and heavy oil is treated with hydrogen at 200 to 800 atm pressure and at a temperature of approximately 450 C. With the aid of a catalytic material, the coal is liquefied under these conditions and forms a crude oil; which, with further hydrogenation and refining, is converted to gasoline. It is believed, at the present time, that Germany is producing some 5,000,000 tons of gasoline annually by this process.

When it became apparent that there would be a shortage of fuel oil in certain parts of the United States, experiments were made to determine the minimum amount of hydrogenation required to convert coal to the heavy viscous type of oil that is used for fuel on shipboard and in industrial plants. It was found that a fuel could be produced by hydrogenation at pressures of 1000 psi which would meet the specifications for No. 5 fuel oil of the American Society for Testing Materials. It contained only a few tenths of a per cent of ash and the yields from Pittsburgh-bed coal were in the neighborhood of 130 gal of oil per ton of coal treated. Of course, the cost of the oil obtained by this method probably would be 3 or 4 times the normal cost of fuel from petroleum. Nevetheless, this cost is not excessive in relation to the real value of such oil for marine use. There is good chance that further research will lead to lower costs; probably not more than one-half those now estimated and possibly not more than 8 or 10 cents a gallon.

COMMENT BY W. C. HARPSTER[5]

Stability of Oil-Coal Mixtures. Attempts during the past 25 years to stabilize a mixture of oil and pulverized coal by the addition of so-called "fixateurs" have been, in the main, disappointing. This, the writer believes, is due in large measure to the instability and complexity of the functions served by the stabilizing agents in accomplishing the so-called stabilization. These involve such complex effects as selective wetting, surface tension, surface energy, relative solubilities, temperature, particle sizes and shapes, electrical charges, etc. For this reason it is believed that the search for stable mixtures of coal and oil will be simplified by the elimination of such "fixateurs" and by endeavoring to find mixtures of coal and oil which, when properly prepared, are naturally stable toward each other without additives. It should be pointed out that, when coal-and-oil mixtures are not naturally stable, under the conditions occurring in their storage and utilization, any stabilization of such mixtures effected by additives may be readily upset by other additions unavoidably occurring, such as water and the mineral salts it contains, and also by chemical, physical, and electrical changes within the suspensions.

It is therefore urged that a practical and commercially successful goal for the development of colloidal fuels should be the production of coal-in-oil suspensions, which are naturally fairly stable without additives and which remain so under the conditions of storage and utilization normally prevailing.

By stability, as used in this connection, it is not implied that a high degree of permanence is necessary in the suspension of pulverized coal in fuel oil. Highly permanent suspensions are difficult to achieve by ordinary methods, and a preferable alternative would seem to be the agitation of the storage tanks at the points of consumption. A sufficient degree of permanence should be achieved to allow of transportation and handling within reasonable time limits, whereas for prolonged periods of storage some means of agitation should be more feasible and economical than the adaptation of measures necessary to bring about a high degree of permanence in the suspensions. An analogy is afforded in the case of ready-mixed paints. After prolonged storage, thorough remixing is required, whereas but little settling occurs in a few days' time after such remixing.

It is to be regretted that early in the development of colloidal fuel a hunt developed for "fixateurs" which had the effect of establishing a wide and unfruitful side issue which was vigorously followed, and the only net result of which appears to have been the building up of a very large amount of patent literature, mostly valueless and now largely obsolete. It had the further effect of establishing the idea that colloidal fuels were a complex subject involving legal and technical complications, retarding development of the main subject.

Peculiar Advantages of Coal-Oil Mixtures. If the coal-oil mixture must be prepared by the final consumer, it is obvious that practically the same equipment will be required for its use as will be needed to burn the coal and oil separately. Some saving of equipment can result by using colloidal fuel and/or fuel oil in the same burners and lines and with the same furnace arrangements. However, a countereffect on such savings will be the need for mixing equipment and possibly additional storage facilities not required where the fuels are burned separately. Also, flexibility in operation will be sacrificed, as is brought out later in the present discussion.

However, it is just as obvious that if a fairly stable coal-oil mixture is supplied, ready made, to a consumer for uses in which the ash in the coal is not seriously detrimental, all of the pulverizing, mixing, handling, and burning equipment required for the burning of the fuels separately or as a mixture will be eliminated. Thus, many fuel-oil-burning operations which are difficult or impossible to convert to the use of coal may be converted to this latter fuel to the extent of the percentage of coal mixed with fuel oil, assuming the efficiency of combustion is the same as when the fuels are burned separately. These include railroad locomotives, cracking coils and pipe-still furnaces of oil refineries, metallurgical furnaces, such as open-hearth furnaces in the steel industry, and reverberatory furnaces in copper smelting, etc.

In the case of locomotive fireboxes it is evident that space requirements do not exist for the installation of separate burner arrangements for two or more fuels. Also, under the present shortage of materials and the need for prompt action for relief of the fuel-oil-supply emergency, it is evident that the conversion of oil-fired locomotives to coal is not feasible. On the other hand, locomotives can be converted to coal almost immediately to an extent determined by the percentage of coal mixed with the fuel oil, if this mixture is handled and burned with existing fuel-oil equipment. Furthermore, as the firebox of a locomotive is water-cooled, troubles from the deposition of slag will be minimized, and as the locomotive disperses its flue gas over wide areas, little trouble should result from the discharge of fly ash.

In converting oil-refinery furnaces, such as cracking coils, pipe stills, and battery-set distillation units, many advantages are offered for the use of colloidal fuels. For the first two types mentioned, many obstacles are presented for conversion to the use of coal. Primary considerations include the intensity and the distribution of the heat released in the furnaces; safety considerations involved in the failure of tubes; the installation of coal- and ash-handling equipment in the frequently congested and

[4] Chief, Fuels and Explosives Service, Bureau of Mines, U. S. Department of the Interior. Published by permission of the Director of the Bureau of Mines.

[5] Petroleum Administration for War, Washington, D. C.

hazardous locations of these units in oil yards. Supplying such furnaces with a coal-oil mixture would have the effect of an immediate conversion of such units to the equivalent of the coal in the mixture while avoiding most of the difficulties experienced by burning coal alone.

In the case of the battery-set distillation units in oil refineries, while most of such furnaces are suitable for burning coal, the scattered location and the small amount of fuel generally burned in each furnace make the installation of coal- and ash-handling equipment extremely expensive per unit of oil used. The use of a high percentage of coal in fuel oil would accomplish a corresponding conversion of such units to coal and avoid the uneconomical expenditure for coal- and ash-handling machinery at the separate units. In the case of these furnaces and of those previously mentioned it is, of course, implied that a ready-made mixture of coal in oil is supplied to the burners.

The conversion of metallurgical furnaces to coal, such as open-hearth units in steel mills, and reverberatory furnaces in copper plants offers the same difficulties as the furnaces previously mentioned. To these difficulties must be added the effects of intense heat concentration on the larger burners required for straight conversion to pulverized coal, and of the large amount of ash thus introduced. Coal could be added to the fuel oil, however, to an extent limited by the effects of the resultant ash.

Disadvantages in the Application of Coal-Oil Mixtures. The users of liquid fuels in marine operations have long since recognized that the contamination of such fuels by salt water is unavoidable, and they have therefore adapted their equipment and operating procedure to such a contingency. As water is heavier than fuel oil, all of the connections for cleaning out and flushing of tanks, bunkers, bilges, etc., have been located at the lowest points and the inlets to the suction lines of tanks and bunkers are located well above the low points. If an oil were supplied which is heavier than water, the connection would need to be reversed, as the water would come to the top of the tanks and bunkers instead of going to the bottom. The specifications of all colloidal fuels so far available show them to be heavier than water, which would introduce the foregoing difficulties. Also there is the possibility that the addition of salt water may have a flocculating effect upon the suspensions of coal in oil.

A third difficulty in the use of colloidal fuels for marine work arises in connection with the greater ash content. In the restricted space available in vessels of all kinds, small furnaces must be built which require very high combustion rates, frequently reaching such figures as 11 or 12 lb of oil per cu ft of furnace volume, corresponding to heat releases of 225,000 Btu per cu ft or more. Combustion rates of such intensity must invariably result in the slagging of the ash in the coal which, together with the small-sized closely spaced tubes of marine boilers, may introduce an extreme difficulty in the satisfactory operation of such boilers with colloidal fuels.

A further drawback to a widespread adoption of colloidal fuels during a period of emergency in the fuel-oil-supply situation is the fact that the introduction of pulverized coal into fuel oil is actually a contamination of the latter, and, therefore, further limits the volume of fuel oil which is available. An ash content of 0.1 per cent is high for fuel oil and limits its application in many cases. However, the introduction into fuel oil of 40 per cent by weight of the mixture of coal containing 6 per cent ash will result in a liquid fuel containing about 2.5 per cent ash.

In periods of fuel-oil emergency, such as the present, the use of colloidal fuels obviously effects less conservation of fuel oil than can be obtained by the use of 100 per cent coal where installations for so doing can be substituted for those burning oil. In such cases, and for such purposes, the use of colloidal fuel would be disadvantageous.

Some Undetermined Factors. While the questions of stability, burner performance, flame characteristics, operation of heaters, etc., are by no means completely answered, at least a certain amount of information is available on such points. Other factors of importance, however, are completely unknown. These include the effect upon the ash in the coal when burning the latter in suspension in fuel oil. Is the slagging tendency of the ash accelerated or reduced compared to burning the coal separately?

Another question of greater importance is in regard to the comparative efficiency of combustion of fuel oil and coal when burned as a so-called colloidal mixture and when each fuel is burned separately.

It is the writer's opinion that combinations can be made for given installations in which considerable sacrifice in speed and efficiency of combustion will result by using the coal-oil mixture instead of burning the two fuels separately. Where two fuels which differ in combustibility must compete for the same supply of primary air, the fuel of higher combustibility interferes with the normal combustion cycle of the less combustible fuel. The initial reactions of combustion are extremely critical, and any interference therewith has a profound effect upon the speed and final results. About the middle of the nineteenth century, Bunsen and his co-workers showed that by introducing a certain amount of air, now called primary air, into a combustible gas before it was ignited, a type of flame could be obtained which could not otherwise be duplicated. If only secondary air were used, no changes in proportions or methods of admission gave the same results. Secondary air in this case means air admitted after ignition has occurred. An analogy is afforded by the fact that one of the first lessons learned by combustion engineers is that it is easier to prevent the formation of smoke and soot than to burn them after they are formed.

It has been the writer's experience that the proportion of primary air which is required for the most satisfactory combustion of various fuels depends upon their "combustibility." Discussion of this term is left to a later paragraph in order to cite an illustration from actual experience. In a case where fuel oil was burned in industrial furnaces with steam-atomizing types of burners and where high-pressure fuel gas was also utilized in the same furnace, the thought naturally occurred that by using this high-pressure gas instead of steam in the oil burners, an appreciable saving could be accomplished. It was found that, while a good degree of atomization could be obtained by using gas instead of steam, it was very difficult to obtain proper flame distribution in the furnace and to avoid the production of smoke. When the two fuels were burned in separate burners, thus allowing separate control of the primary air to each fuel, no difficulty was experienced in obtaining flame control and in avoiding the production of smoke. Therefore it appears quite possible, in the case of colloidal fuels, to prepare mixtures in which the components vary sufficiently in "combustibility" to cause an appreciable loss in the rapidity and efficiency of combustion, compared to the results obtainable when they are burned separately.

The term "combustibility," while difficult of exact definition, may be considered as a complex property or function including such factors as rates of diffusion, hydrogen-to-carbon ratios, vapor pressures or volatility, chemical and physical structure, and, in the case of coal, the amount, distribution, and character of the mineral matter, or ash. The term "combustibility," as applied to fuels, is more or less in the same category as the term "oiliness" as applied to lubricants.

It seems quite probable that a mixture of high-ash low-volatile anthracite coal, even though finely pulverized, could pass practically unburned through water-cooled furnaces such as in locomotive-type boilers. While the variation in combustibility of the various bituminous coals may not be sufficiently great to affect appreciably their performance when used in colloidal fuels, it would seem that over the entire range of solid fuels from anthracite coal, or coke, to

lignite, a sufficient difference exists in combustibility to warrant consideration.

Summary and Conclusions. It is recommended that the development of colloidal fuels be directed toward the elimination of "fixateurs" and hence toward the production of suspensions which are reasonably stable during the comparatively short periods required for distribution and preliminary handling operations. A degree of stability suitable for long-term periods of storage does not appear to have been established on a positive and commercially feasible basis. Agitation of storage tanks or remixing after settling appears to be more practical and economical for long-term storage.

Many applications exist for the utilization of colloidal fuels as a means of relieving fuel-oil shortages. However, overoptimism and improper application of colloidal fuels for such purpose should be avoided in order not to handicap and check their development and damage production. A greater degree of conservation of fuel oil can be made by the complete conversion to coal where installations are suitable. Using 100 per cent coal requires but little more critical materials than colloidal fuels where the latter are prepared and burned by the ultimate consumer. The most promising method of using colloidal fuels for relief of the existing fuel-oil shortage and for the conservation of critical materials appears to be in the preparation of colloidal fuels at central points and their distribution ready for use by the ultimate consumer.

If colloidal fuels so prepared were available in large quantities, they could be used for the partial conversion of certain fuel-oil-burning operations which could not otherwise use coal. These include railroad locomotives and certain industrial and metallurgical furnaces.

Additional knowledge urgently needed includes the effect upon the slagging character of the ash in the coal when the latter is burned as a suspension in fuel oil. Another uncertainty is in respect to the speed and efficiency of combustion of a colloidal fuel in which the components vary widely in their degree of combustibility. It would seem probable that coals low in volatile matter and high in fixed carbon and ash would be difficult to burn efficiently when mixed with fuel oil, particularly in water-cooled furnaces. For this reason, careful comparative tests are necessary of the efficiency, when burned separately, of such fuels and of the efficiency obtainable when they are burned in the combinations of colloidal fuels.

COMMENT BY J. E. HEDRICK[6]

This paper presents a comprehensive evaluation of the information and data previously reported on oil-coal mixtures. It also points out the problems which deserve further investigation in connection with the use of this fuel. The viewpoints given in the conclusions should serve as guideposts to anyone who finds it desirable or necessary to use oil-coal mixtures.

In view of the unsatisfactory past experiences with stabilizers and the immediate need for using oil-coal fuels, it is recommended that attention be focused on means of utilizing these fuels without the addition of such substances. The only completely satisfactory stabilizers known are expensive and involve strategic materials. Fuels of sufficient stability can be prepared simply by mixing washed bituminous coal having a medium or high ash-fusion temperature with such heavy fuel oils as cracked residuums or lubricating extracts. Of course, the coal should be 95 to 98 per cent through a 200-mesh screen but such sizes are being produced readily in existing coal-pulverizing equipment. The volume concentration of the coal in the mixture is an important factor, both as regards stability and flow characteristics.

The writer has handled many mixtures of oil and coal at widely varying temperatures and different coal concentrations in pipes, pumps, and tanks. The only appreciable settling occurs in storage. It should be emphasized that mixtures can be stored in open tanks where air agitation or even hand paddles can be used to overcome this difficulty.

Oil-coal fuels could be made in centralized plants, preferably where the coal grinding is done. This would obviate the necessity of transporting pulverized coal. It happens that there are several locations in this country where coal and oil are produced close together.

Combustion studies are perhaps the most important to be made. Such tests should be made on full-scale equipment and should be of sufficient duration to give conclusive results. Steam-atomizing burners have proved satisfactory where the oil-coal fuels are preheated to about 150 F.

COMMENT BY A. B. HERSBERGER[7]

This paper makes available an excellent summary of scattered information on mixtures of oil-and-coal fuel. In this connection, The Atlantic Refining Company has carried out experimental work to determine whether stable suspensions can be produced and to study their characteristics. The results of this work indicate that a suspension sufficiently stable for practical use can be prepared. We have not conducted large-scale combustion tests or verified our work by plant-scale storage tests. Our data will be made available in connection with the work undertaken as a result of a conference held on coal-in-oil fuel between various government agencies and oil companies.

A stable suspension of coal in oil can be obtained by proper grinding of the coal and mixing with the oil. The choice of coal and oil is important. The use of stabilizers, as frequently mentioned in this paper, in our opinion is unnecessary. Their use will materially increase the cost of the fuel.

In considering the use of this fuel, it should be remembered that its attractiveness at this time is due to a shortage of heavy fuel oil. This shortage is a result of the lack of transportation. Any method to be considered for the production, distribution, and use of this fuel should, therefore, not add an additional load on the already overstrained transportation facilities and must require a minimum of new equipment. Plans which require special railroad cars or trucks to transport pulverized coal, or require the installation of agitation equipment by the consumer to keep unstable suspensions from settling do not meet these requirements.

The writer would like to emphasize the importance of obtaining large-scale combustion tests. These tests are necessary not only to determine whether the fuel can be burned satisfactorily but also to obtain consumer confidence.

COMMENT BY HENRY KREISINGER[8]

This paper ably summarizes the available information on the use of mixture of oil and coal as fuel in steam boilers. Much of this information relates to making the mixture stable so that the pulverized coal would not settle down. There is very little information on the burning of the mixture. The fact that all trials of burning this fuel have been discontinued is suggestive that the results were not satisfactory, or that the use of the fuel could not be justified economically.

Much of the information is sketchy and incomplete because a large part of the work was done a comparatively long time ago. In the course of time, some of the facts have been forgotten and have been replaced with opinions and prejudices. As a result of this lack of definite information on the use of this fuel, the discussion of this paper is largely a matter of impressions and opinions. Some of the trials were made abroad, and the men who were intimately connected with them are not available for questioning on the results that were obtained. The information that we have is largely second-hand and legendary.

[6] Chemical Engineer, Concord, Calif.

[7] Research and Development Department, The Atlantic Refining Company, Philadelphia, Pa.

[8] Engineer in Charge of Research and Development, Combustion Engineering Company, Inc., New York, N. Y. Mem. A.S.M.E.

It seems that the cost of preparing the fuel mixture would be too high and economically unjustifiable. The coal would have to be pulverized to a high degree of fineness in order that the coal particles would remain in suspension in the oil. This high degree of fineness would greatly increase the power consumption and maintenance and lower the capacity of the pulverizing equipment. Additional equipment would be required for making the mixture, and very likely the tanks at the point of use would have to be provided with stirring apparatus to maintain the coal in suspension. Some of this large-scale mixing apparatus is not available at present and would have to be developed.

If all the plants which might be willing to use this mixture as fuel for making steam were to be provided with coal-pulverizing equipment and mixing apparatus, the demand for such apparatus would put a severe burden on the manufacturing facilities and supply of raw material for making such equipment. There is no doubt that, with the large number of installations which would have to be made there would be a great deal of duplication of spare equipment.

The duplication of spare equipment would be greatly reduced if a few fuel-preparation plants of large capacity were built, where the mixture would be prepared and then distributed in tank cars to individual users. The users of the fuel would still have to have some mixing equipment to stir the mixture before use. A large number of tank cars would be required for the distribution of this fuel. These tank cars may not be available, and might have to be built, thus putting additional burden on the car-building plants.

It is doubtful that as high capacities of the steam-generating equipment could be developed with this mixture as was possible with straight fuel oil. The presence of ash in the coal would be the principal cause of the reduction in the capacity. Refractory-lined furnaces which were able to burn straight fuel oil with moderate wastage of the furnace walls would find this wastage excessive with the mixture and would be compelled to reduce the capacity. The ash in the coal would also tend to deposit on the heating surfaces of the boiler and superheater and clog the gas passages, in spite of frequent use of soot and slag blowers, thus tending to reduce the capacity of the steam-generating equipment.

While fuel oil and pulverized coal when burned separately may be burned efficiently in a given installation, we are by no means certain that the same high efficiency could be obtained when the two fuels are burned together in a mixture. When pulverized coal is burned alone, it is supplied to the furnace in the form of a dust cloud. The drier and finer the coal, the more ignitable is the dust cloud which enters the furnace. Presence of moisture or of a small quantity of oil used for dedusting the coal makes dust-cloud formation more difficult. The oil in the mixture would very likely make the small particles of coal stick together so that, when the coal is heated and a part of the oil is gasified, the residue would form a piece of solid fuel much larger than the size of coal particles in the ordinary burning of pulverized coal. The fuel oil might burn efficiently alone. It is easily dispersed into very small droplets or mist which burns readily without leaving much solid residue. The presence of the coal in the mixture may interfere with effective atomization. The oil may stick to the dust particles and may not be broken into mist as easily as when burning alone. The result may be a high percentage of unburned carbon residue leaving the furnace, and low combustion efficiency. It is probable that this low combustion efficiency was one of the causes why larger-scale trials of using this fuel for making steam were discontinued. The high cost of preparing the mixture together with the cost of changing over the installation to the new fuel, and the lower capacity obtainable, might have been other causes.

COMMENT BY H. H. LOWRY[9]

In much of the previous discussion emphasis has been placed on the cost of fine-grinding of coal to make a stable mixture. There is a method of making a stable mixture which does not require fine-grinding, which has not so far been mentioned. The writer refers to a method described by a Japanese investigator, Miyazaki.[10] The following brief quotation is taken from an abstract of the paper:

"Thirty to 40% of finely powd. coal of 1–10 mesh was added to heavy oil, and heated with H in an autoclave with stirring; the optimum condition was to heat to 370–430° for 1 hr. under the first pressure of more than 20 atm. An example of the analysis of the manufactured colloidal fuel (coal content 40%): d_{15} 1.065, viscosity (30°) 410 Redwood sec., solidifying point—11°, ash 0.84%, calorific value 9353 cal./kg., flashpoint 78°. It was stable more than 6 months, and pptn. was not observed during 2 years. Observation of the state of dispersion of coal particles in the colloidal fuel by filtration, ultramicroscope, and pptn. by addn. of benzene showed coarse suspension 11.2, mol. dispersion 26.6, colloidal dispersion 62.2%. The action of H in dispersing oil and on coal was shown to be deoxidation, which caused the splitting of coal and hence the coal was made colloidal."

It is believed the Bureau of Mines has studied this method to some extent, and the writer would ask if the author is in a position to inform us whether the results reported by the Japanese have been confirmed.

Also does the author consider that grinding of the coal in oil produces a more stable suspension? This question is raised because it is known that fresh coal surfaces rapidly oxidize and become hydrophilic and therefore would not be expected to be as easily wet by oil as an unoxidized surface.

Another question is raised by the author's proposal of a central plant to produce the mixture of coal and oil for distribution to the consumer. If there were more than one such central plant using different oils, what would be the danger of the consumer, who might secure his fuel from either central plant, of finding that a mixture of the two stable fuels would be unstable and that the coal would settle out of the mixture?

COMMENT BY RALPH A. SHERMAN[11]

Either fuel oil or pulverized coal is an excellent fuel for boiler furnaces when burned alone. That they can be burned in mixtures has been well proved by the experiments cited by the author, but it has also been properly stressed by the author that, for normal peacetime conditions, no advantages of such mixtures have been conclusively proved other than the somewhat greater calorific value of a given volume of fuel; this advantage is of value only in marine or locomotive practice where increased "cruising range" is desirable.

Under conditions of war and the resultant shortage of fuel oil in certain sections, the possibility of the replacement of a considerable fraction of the oil requirements with pulverized coal mixed with the oil may be important. Its field of application would appear, however, to be limited to the moderate-sized boiler plants. For larger plants where the boilers have the proper size and design of combustion space and facilities for handling the ash, the only saving in material by the use of a mixture of coal and oil instead of coal alone would be the piping to convey the coal to the burners and the burners themselves. This is usually a small part of the total weight of steel required and, if available, its cost would be less than that of the equipment for making the mixture of the coal with the oil and the labor and bother required.

For the smaller plants, even though they could use pulverized coal alone, the

[9] Director, Coal Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa.

[10] "The Manufacture of Colloidal Fuel-I," by Miyazaki, Reports of the Tokyo Imperial Industrial Research Institute, vol. 34, no. 2, 1939, pp. 1–50.

[11] Supervisor, Fuels Division, Battelle Memorial Institute, Columbus, Ohio. Mem. A.S.M.E.

use of the mixture might be justified on the basis of the saving of steel if the mixture is prepared in a central plant for distribution by tank car or tank truck. A pulverizer with a capacity of 20 tons per hr will require less steel proportionately than four mills each of which has a capacity of 5 tons per hr.

The central plant for preparation of the mixture is more feasible, in the writer's opinion, than the central plant for preparation of pulverized coal to be distributed for mixture with the oil at the plants where it is to be burned. Although the transportation of pulverized coal by tank car has been proved feasible, and its transportation by tank truck has been shown practical by extensive experience in England and Europe, this equipment is not now available and will require much steel for its construction.

The author has rightly pointed out the need for a survey of the oil-burning plants of the eastern coast to determine the best policy to follow not only in general but also for specific plants, that the most oil may be saved with the least use of steel and other critical materials. If such a survey should show, for example, that, in a group of plants, one half could use pulverized coal by itself, more oil could be saved at less expense if they were converted to coal, and the remainder continued to use oil alone, than if the entire group was converted to colloidal fuel in which 40 per cent was coal.

COMMENT BY JOHN VAN BRUNT[12]

The paper appears to be directed to the possibility of utilizing colloidal fuel in stationary boilers which were designed for burning oil and probably of sizes ranging from 250 to 600 or 700 hp, built with refractory furnaces.

Because of the shortage of fuel oil the economics of the problem is perhaps not important when considered in relation to the necessities that undoubtedly exist in many cases where those having boilers of the kind described will be unable to obtain enough oil to take care of their load requirements.

Many features of the author's paper were brought out in a paper by J. E. Hedrick.[13] The writer discussed that paper[14] with relation to economics of the problem. This discussion, therefore, will not touch on the economics but will look into the faults or objections which make the use of colloidal fuel impracticable in the described boilers. Such limits will be found in the operating difficulties. That the author recognizes these difficulties is evident as indicated by the caution to use only coals of low ash high fusion temperature.

As applied to stationary boilers and furnaces designed for fuel oil, the problem is to obtain equal or nearly equal efficiencies with mixtures of coal and oil ranging from 40 to 60 per cent coal, and to be able to operate without interruptions, for reasonable periods of time, neither for repairing furnaces nor for cleaning the heating surfaces in the gas passages.

Experience has shown that the stationary oil-burning furnaces with refractory walls may be operated with excellent results at 45,000 to 50,000 Btu release per cu ft of furnace volume, and that, for corresponding steam capacity when burning pulverized coal, the combustion rate should not exceed 14,000 to 16,000 Btu per cu ft.

If a 50 per cent mixture is assumed, the coal in such a mixture would be burned at a rate of 23,000 to 25,000 Btu with a considerable loss due to unburned carbon. Since, however, the economy is not controlling we only have to consider the operating conditions.

With the given heat release in an all-refractory furnace there would undoubtedly be trouble both as to fusion of ash on refractory walls and to ash deposits on the boiler heating surface. If, however, to such release of Btu from coal we add an equal amount of heat from oil, the temperature from the furnace will be about the same as if oil or coal alone were burned, but the presence of ash in such a furnace would result in the rapid destruction of refractory walls. Even if we assume the coal to have but 4 per cent ash, the amount of ash per cubic foot of furnace volume would be approximately 75 per cent of the amount that would be released per cubic foot in a normal refractory-wall pulverized-coal furnace, but because of the high heat release, the temperature in the furnace would be so much higher that the destruction of the wall would be at a much more rapid rate.

Further, the heating surfaces would be rapidly fouled and the ash accumulations would be such as to necessitate frequent shutdowns for manual cleaning. Furnace-exit temperatures would be so high that fixed soot blowers could not be maintained, and if superheaters were used trouble could be expected continually in the rapid plugging of the gas passages through the superheater.

The writer, therefore, believes that colloidal fuel cannot be satisfactorily used in normal refractory-wall oil-burning furnaces, except at a reduced capacity approximating one half of that with fuel oil alone. It is suggested therefore that, if possible, such furnaces be enlarged to the maximum possible extent and provided with water-cooled walls and pulverized fuel burned without a mixture of oil, otherwise the reduced capacity must be expected if coal and oil are burned in furnaces designed for burning oil.

AUTHOR'S CLOSURE

The interest in this paper on the burning of oil-coal mixtures, as evinced by the extensive discussion, the penetrating analysis of the advantages and disadvantages of a fuel of this type, and the new data brought out have been very pleasing to the author. Every discusser has presented his position, whether favorable or unfavorable to the use of a mixed fuel, with clear logic that has added to the understanding of the problems that are involved. Each discussion should have an individual reply but space limitations make this impossible. Perhaps of equal interest would be a brief indication of the future prospects of the oil-coal fuels.

Since this paper was given in October, 1942, the need for fuels that can be substituted for oil has deepened. For industrial furnaces, only two solutions appear feasible—complete conversion to coal or the use of an oil-coal mixture. The discussion has suggested that the conversion of 30 per cent of the industrial furnaces completely to coal would save just as much oil as the conversion of 100 per cent to an oil-coal mixture and would not use any more critical materials. Calculations on these two bases have now been made for groups of plants using up to one million barrels of oil annually. The oil-coal fuel possesses a decided advantage and uses about one third as much steel for the saving of a given quantity of oil. It also avoids shutdown of the plant for the installation of coal-handling and burning equipment. Railroad sidings and space do not have to be provided at each plant to bring in coal and to store it.

At present at least three oil companies and one coal company are engaged in active investigation of the preparation and burning of oil-coal fuel. The combustion tests are being made on modern boilers of fairly large size operating continuously on the mixed fuel for periods of several weeks. Complete data are being collected concerning the effect of the coal ash on the furnace, the efficiency of the boiler, and the stability of the suspension in storage and through the pumps and preheaters. This work will furnish a clear-cut picture of the conditions under which colloidal fuel can be used and the effect it will have on boiler output. If this work is successful there is sound reason to believe that oil-coal fuels will play a prominent part in saving large quantities of oil in the latter part of this year.

W. C. SCHROEDER.[15]

---

[12] Vice-President in Charge of Engineering, Combustion Engineering Company, Inc., New York, N. Y. Mem. A.S.M.E.

[13] Author's footnote 33.

[14] MECHANICAL ENGINEERING, vol. 63, 1941, p. 920.

[15] Assistant Chief, Fuels and Explosive Service, Bureau of Mines, Washington, D. C. Mem. A.S.M.E.

Standards for Army Ordnance Finishes

COMMENT BY D. A. GURNEY[16]

The following comments are submitted, not as a discussion or a criticism of this paper,[17] but to show what additional work had been done in the Ordnance Department on this project. This work is related only to establishing better means for designating surface finishes on ordnance drawings.

A study was made of the various methods which have been used or proposed for indicating surface finishes on mechanical drawings with a view to improving our methods of designating such finishes. Although the literature on the subject of surface finishes is now rather extensive, it is remarkable how little has been done with regard to indicating such surface finishes on drawings. Table 1 which is presented herewith for the files of Sectional Committee B-46 shows in various columns the methods of symbolizing ordnance finishes used or proposed by various agencies, and including those from A.S.A. Sectional Committee B46, two systems in use by the Ordnance Department, one system by the General Electric Company, one system proposed by A.S.A. Sectional Committee Z-14 (this system is now being revised to conform with the B-46 report), one system used on British drawings which have been received in this country, and one system advocated by Herr Schmaltz of Germany.

Since no system which appears to be better than that of Sectional Committee B-46 was discovered in this study, the use of the system proposed therein is now being carefully considered by the Ordnance Department. However, the new designations of surface finishes are not being adopted at this time as it seems unwise to modify our system, particularly in the midst of the present emergency. The progress on the finishes and their designations in industry is being carefully followed, and whenever a system satisfactory to industry is promulgated its adoption will be given serious consideration by the Ordnance Department.

COMMENT BY R. S. HACKETT[18]

It is very gratifying to learn of Ordnance Department efforts to eliminate inconsistent interpretation of finish symbols. The author's excellent exposition contributes a very clear review of the current problem and a worthy proposal for improvement. However, the sample-finish system suggested (and indeed already in limited use) suffers the criticism of being a stop-gap or makeshift improvement defensible only on the grounds of exigency.

The American Standards Association Committee B-46 has proposed entirely adequate specifications for degrees of surface roughness conventionally required today. The symbols, dimension used, and the range embraced by the table represent logical selections. The standards accomplish half the purpose of producing consistently uniform finishes for a given specification denoted by symbols. The full accomplishment of the committee's purpose awaits only the development of cheap, rapid, and accurate means for measuring the extent of irregularities encountered in a finished surface. Any standard is worthless unless the dimension selected is truly significant and means are available for quantitative measurements in that dimension. Fifty years ago, the Swiss watchmaker could make two parts mate with differential diameters of perhaps 100 microns, but any standard that he might have established for duplicating that performance would have been utterly meaningless if the dimension "micron" were used, since he could not measure to that accuracy.

The analogy is unfair with respect to our present circumstances, as the B-46 standards are in thoroughly practicable and measurable dimensions. The situa-

[16] Chief Engineer, Artillery Branch, Ordnance Department, U.S.A., Washington, D. C.

[17] "Development of Standards for Army Ordnance Finishes," by Mary R. Norton, MECHANICAL ENGINEERING, October, 1942, pp. 703–717.

[18] Engineer, United States Guarantee Company, New York, N. Y. Mem. A.S.M.E.

TABLE 1 CHART GIVING VARIOUS SYSTEMS FOR DESIGNATING SURFACE ROUGHNESS

SYMBOLS A.S.A. B-46	MICROINCHES	EXAMPLES (FROM A.S.A. B-46)	SYMBOLS ORD. PAMPHLET NO. 2567	SYMBOLS ORD. CHART URAX-6	SYMBOLS GENERAL ELECTRIC CO.	SYMBOLS A.S.A. Z-14-1	SYMBOLS BRITISH (N.Y. NOTE SHEET NO.1)	SCHMALTZ GERMANY MICRONS	SCHMALTZ GERMANY MICRO-INCHES
$\sqrt{\frac{1}{8}}$	.25	HIGHLY POLISHED SURFACES USED LARGELY						.0039	.25
$\sqrt{\frac{1}{4}}$	.5	FOR LABORATORY WORK, ETC.						.0059 .008	.33 .40 .50
$\sqrt{1}$	1.	VERY FINE FINISHING OPERATIONS, GRINDING,					P	.008 .01 .0126	.63 .80 1.00
$\sqrt{2}$	2.	HONING, LAPPING, BEST CURRENT M'F'G.	POLISH			$\sqrt{D}$	P	.032 .04 .05	1.26 1.58 2.00
$\sqrt{4}$	4.	PRACTICE, MEASURING GAGES, ETC.			f^1		P	.06 .08 .10	2.37 3.17 3.99
$\sqrt{8}$	8.	FINE FINISHING OPERATIONS GENERALLY HAVING	fg	LAP	f^2		I G	.13 .16	5.03 6.35
$\sqrt{16}$	16.	SHINY APPEARANCE. DIAMOND OR HARD METAL	ff	fg & ff	f^3	$\sqrt{B}$ OR $\sqrt{C}$	I G	.20 .25 .32 .40	7.97 10.04 12.64 15.92
$\sqrt{32}$	32.	TURNING AND BORING, GOOD FINISH GRINDING, HONING, SMOOTH MOLDING, ETC.		ff	$f3\frac{1}{2}$		I G	.50 .63 .80	20.03 25.23 31.77
$\sqrt{63}$	63.			f & ff	f^4			1.00	40.00
	125		f	f	f^5	$\sqrt{A}$		1.59 2.51	63.4 100.5
$\sqrt{250}$	250	TURNING, BORING AND MILLING OPERATIONS.			f^6			3.98	159.3
	500				$f6\frac{1}{2}$		X	6.32 10.02	252.4 400.2
$\sqrt{1M}$	1000		cf		f^7			15.88	634.3
	2000		g		f^8	$\sqrt{A}$	X	25.17 39.90	1005.3 1593.4
$\sqrt{4M}$	4000	ROUGH CASTINGS, ROUGH MACHINING OPERA-			f^9			63.24	2525.5
		TIONS, USUALLY FOR CLEARANCE, WHERE					X	100 126 158.6	4002 5040 6346
$\sqrt{16M}$	16000	SMOOTHNESS IS NO OBJECT, AND WHERE						199.7 251.3 316.4 398.6	7980 10060 12644 15944
		FURROWS ARE CLEARLY VISIBLE AND					X	501.6 631.5	20073 25272
$\sqrt{63M}$	63000	EASILY FELT.						795.1 1001 1260	31817 40068 50433
								1586	63500

tion calls for speedy and virile attack on the side of making the measuring devices more accurate, reliable, simple, and commonplace. The ultimate solution is decidedly not in the direction of qualitative comparisons, subject to psychological phenomena of tactile and visual sensitivity, experience, age, and fatigue.

Perhaps the qualitative comparison of standard sample with production piece is the most practicable procedure during the present emergency, particularly as instrument designers and manufacturers are urgently preoccupied. Apparently, the General Electric Company and others have had favorable results from the use of samples, and it is readily admitted that the qualitative sample-comparison method represents a substantial improvement over the existing system which really consists of specifying that a surface shall be "as smooth as the average surface previously judged to be satisfactory to the designer specifying this finish symbol."

Because increases in production as well as in the required quality of finely finished surfaces make the difficulty of finish specification exponentially more serious, continuous attention to the problem should be given, and improved measuring devices produced.

The writer suspects that ultimately the height of irregularity in a finished surface may not remain the exclusively significant dimension. Perhaps the height, breadth, and frequency of irregularities per unit area or linear length may bear significance. The function of the smooth surface must determine just what dimensional characteristics are required, just as function quite logically determines the material of which a surface shall be fabricated.

As the author indicates, the most promising "smoothness" measuring device now appears to be some type of profilometer. The diamond-stylus instruments enjoy the advantage of relative simplicity and facility of operation. Development of optical or electrical magnification of stylus displacement may prove the most practical research program.

In conclusion, it should be noted that the Ordnance Department's effort toward a uniformity of finish for a specified smoothness does represent an improvement; but alternative means, especially quantitative rather than qualitative should be sought diligently and immediately.

COMMENT BY C. R. LEWIS[19]

The author has described a conversion system for the translation of previous ordnance-finish symbols into microinches rms as specified in the A.S.A. "Proposed American Standard for Surface Roughness." The introduction of a quantitative basis for describing finishes cannot help being advantageous, especially in ordnance work, where a uniform product must be obtained from a great many different sources.

The series of standard-finish samples, described in the paper, should be useful as a rough indication of the desired surface finish. The author has recognized their limitations, but it may be useful to point out again the difficulties which may arise from too great dependence upon them. An occasion recently came to the writer's notice in which a comparison of finishes was desired between a flat and a cylindrical surface. Several people judged that the cylindrical surface was as smooth or somewhat smoother than the flat surface. Measurement of the surface showed a 12-μin. finish on the flat piece and a 40-μin. finish on the cylindrical piece. As a result of this and similar experiences, standard specimens for visual comparison of finishes are required to be of the same material as the work, having the required degree of finish, the same type of finish, and approximately the same contour. It is realized that such a requirement involves the preparation and measurement of a large number of surfaces and is not practical for primary-finish standards, as described by the author. It can be done, however, at each manufacturing plant. At Chrysler it has proved necessary to meet such a requirement to obtain consistent and effective visual inspection control of surface finishes.

The introduction of a microinch standard for ordnance finishes will undoubtedly lead to some difficulties, as is the case with all new methods. The system has, however, been used by the Chrysler Corporation for several years with very satisfactory results, and its use by the Ordnance Department should be equally satisfactory.

COMMENT BY W. MIKELSON[20]

The author is to be complimented for the very fine paper presented, and for solving an important production problem, at a time when accurate inspection and rapid production are so vitally necessary to industry. The performance of a smooth-machined surface depends upon the dimensional characteristics of the surface irregularities, and the author's approach to the problem, namely, that of describing these characteristics with the aid of an actual gage specimen, is one which we have used in the General Electric Company for the past 10 years and which we have found valuable in maintaining quality at low cost in our production equipment.

The dimensional characteristics of the irregularities in a machined surface can vary considerably and depend upon the method of finishing and the material used. They can be partly described by the following items:

1 Surface roughness.
2 Surface waviness.
3 Direction of surface irregularities.
4 Pattern of these irregularities.
5 Surface profile.
6 Contact area with mating parts.

Stylus- or needle-type instruments are now available which measure only one of these many characteristics, i.e., surface roughness. The functional or performance characteristics of a surface depend to some extent, however, upon each of the many dimensional characteristics described. The measurement of any one alone does not qualify or define the performance of that surface. An example of this was cited in a current paper.[21] The authors gave results on bearing performance on surfaces ranging from 1 to 10 μin. in roughness. They found that there was no consistent correlation between the measurements and the performance. Another example is cited in an article[22] by O. R. Schurig. In this case, a grit-blasted journal was compared with a ground and polished journal of one third the roughness. When tested in an Almen testing machine, it was found capable of taking three times the load of the ground specimen, without seizing.

Until practical instruments usable by engineers and mechanics are available, which adequately describe and measure all dimensional characteristics of a surface, and until more research work is done of a nature similar to that cited, to relate the pertinence of each characteristic to the functional performance required of the surface, some simple practical method is needed to describe surfaces for design and production, in a way which includes as many of the characteristics involved as possible. The General Electric system in many respects is similar to the system that has been announced by the Ordnance Department, in which sample gage specimens are used and designated by a symbol on the manufacturing drawing. Each symbol used, however, designates a specific value of surface roughness rather than a wide range of values determined by the application as used for ordnance finishes. The symbol used is an "f," with an attached number, f^1, f^2, f^3, etc.

There are ten degrees of roughness, varying in 2-to-1 steps from 4 μin. to 2000. Each symbol is described by one

[19] Engineering Division, Chrysler Corporation, Detroit, Mich.

[20] General Engineering Laboratory, General Electric Company, Schenectady, N. Y.

[21] "Surface Finish of Journals as Affecting Friction, Wearing-In, and Seizure of Bearings," by R. W. Dayton, H. R. Nelson, and L. H. Milligan, MECHANICAL ENGINEERING, October, 1942, pp. 718–726.

[22] "How Should Engineers Describe a Surface," by O. R. Schurig, MECHANICAL ENGINEERING, vol. 62, 1940, pp. 703–711.

or more sample finishes, all machined to the same roughness, on a metal specimen block, to illustrate differences in surface characteristics encountered in practice. For example, two surfaces are represented on the smoothest specimen, one is lapped and the other is honed. These finishes are available to design engineers and draftsmen, shop mechanics, and inspectors. They are used:

1 To indicate to the design engineer and to the draftsman the smoothness and appearance of various degrees of finish, and to permit the selection of an exact type of smoothness for the functional purposes intended.

2 To enable the shop mechanic to visualize the degree of roughness designated on a drawing.

3 To enable the shop mechanic and inspector to inspect the product surfaces by comparing them against the proper specimen.

The surfaces represented on these specimens illustrate our standard "garden variety" finishes. When finishes differ widely in appearance from the samples shown on the gage specimen, special gages are made up. They are numbered in the same manner as the standard set and are built to measure the same roughness. The method of inspection in all cases consists of comparisons by sight and feel with the surface being manufactured.

The continued use of this system for the past ten years has given good results and has established confidence in the method. We offer it as a suggestion to others who may have similar surface-finish-inspection problems to solve at this time. The merit of the system is that it includes and describes many of the dimensional characteristics of a surface instead of only one, as would be the case if surface roughness only were designated on a drawing. Furthermore, a sample finish specimen is an actual representation of the finished product, and hence more useful to design and production personnel, and simpler to use.

AUTHOR'S CLOSURE

The author wishes to thank all who have submitted comments.

Mr. Hackett's viewpoint is well taken. The fact that it is impracticable to provide each ordnance inspector with one of the existing types of surface-roughness measuring devices lends support to his demand for the development of a cheap, rapid, and accurate means of measuring surface irregularities. Use of the reference samples is, therefore, the only feasible means of interpreting standards at the present time. In spite of the fact that the system is only qualitative, it is an *approach* to the general problem of effecting uniform interpretation of finish symbols on drawings. Pending the development of simple measuring devices, the use of reference samples will serve to educate both inspector and producer on the importance of standard finishes. This awakening of a sense of finish-consciousness can in turn facilitate the general acceptance of standardization of surface finishes.

The author agrees with Mr. Lewis that when reference samples are designed for individual manufacturing plants, it would be desirable to have the material and contour as well as the finish of the work exemplified. It is not practical to do this when the reference samples must be applicable to the whole range of ordnance matériel.

Recently there has been a revision of ordnance drawing URAX6 given in Table 2 of the original paper. Finish values for some ordnance matériel have been changed. Also, the 175 value, which is not one of the A.S.A. series of preferred numbers, has been deleted.

MARY R. NORTON.[23]

[23] Associate Metallurgist, Watertown Arsenal, Watertown, Mass.

George B. Karelitz

TO THE EDITOR:

In the passing of Prof. George B. Karelitz on January 19, 1943, the engineering profession suffered greatly and many of us lost a very loyal friend.

Professor Karelitz was born in Russia on January 3, 1895, and received his education in that country. He studied mechanical engineering and naval architecture at the Imperial Polytechnic Institute, Petrograd, finishing these courses in 1917.

Subsequently he became an officer in the Russian Navy, being chief engineer of the cruiser *Askold*. During the years 1918 to 1921 he was consulting engineer for the Northwestern District of Waterways of Russia in charge of wooden shipbuilding and inspection of mechanical equipment. Russia at that time was passing through a political upheaval because of the revolution and Karelitz gradually moved to the Far East, becoming a designer of street railways in Harbin, China, in 1922.

During 1922 Karelitz came to the United States of America and for a period from 1922 to 1923 he was employed as a draftsman with the Red River Lumber Company, Westwood, Calif., subsequently with the Cadillac Company of San Francisco, and later with the Westinghouse Electric and Manufacturing Company, San Francisco.

Having made a connection with the Westinghouse Company in 1923, he ultimately became located in the East at the South Philadelphia plant as a junior turbine engineer and interested himself, among other things, in balancing problems connected with turbine equipment. In 1923 a Mechanics Division had been created in the Westinghouse Research Laboratories, East Pittsburgh. Karelitz established early contacts with this group, meeting again one of his early teachers in Russia, Dr. S. Timoshenko. He joined the staff of this research group in 1925 and became interested in the development of photoelasticity but, because of his eyes, his field of activities was changed to that of lubrication and bearings. His work in this branch of mechanics was very productive and many important technical papers on original research were published. Most of these papers appeared in the Transactions of the Society and dealt with bearing metals and lubrication. At a later date several papers under joint authorship, dealing with photoelasticity and stresses in pipe bends, were also published. During this period he began to take an active part in the activities of the Society and became a member of the Research Committee on Lubrication and later its chairman.

Karelitz was always interested in teaching and took part in the work of the Mechanical Design School organized by the Westinghouse Company. In 1930 this bent for teaching took a more active form and he was appointed assistant professor of mechanical engineering at Columbia University. The following year, owing to needs of industry, he obtained leave of absence to return to the Westinghouse Company as manager of the Marine Division of the South Philadelphia engineering department. He returned again to Columbia in 1933 as professor and was retained by the Westinghouse Company as a consultant as well. During the last eighteen months of his life he spent part of this time in Washington as a consultant for the Navy Department.

Although interested in the subject of lubrication, he took great interest in the Applied Mechanics Division and other activities of the A.S.M.E. He was a member of the Standing Committee on Professional Divisions 1937 to 1942 and was chairman for the year 1941–1942. He was appointed to the Committee on Publications in December, 1942, and represented the Society in its activities with sister societies.

Although born in European Russia, Karelitz never knew Western Europe until he was able to make visits from the United States which he did several times. During 1934 he attended the Fourth International Congress for Applied Me-

chanics, held in Cambridge, England.

Karelitz, known to his associates as George, had a wide circle of friends in fields of interest other than engineering. He was very reticent, only speaking when he had something really important to say. On occasions he could be an interesting story teller and his recounting of his experiences in Russia to escape the aftereffects of the revolution never lost thrill and interest. He was interested in travel and after his visits to Western Europe could talk equally well on such varied topics as the sanctity of the British Museum or the beauty of the Italian lakes.

At future meetings of the A.S.M.E. whenever the subject of mechanics is discussed his absence will be felt by all because George will not be there to add his wise council to the subject under discussion. Apart from this loss to the group associations, many of us will feel the individual loss of a very sincere friend.

JOHN M. LESSELLS.[24]

[24] Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of January 15, 1943, subsequently approved by the Council of the Society.

CASE No. 970 (Reopened)

(Special Ruling)

Inquiry: May seamless casing conforming to A.P.I. Specification 5-A, eleventh edition, April, 1941, Grades J-55 and N-80, Section III, or conforming to Specification S-18 with the following additional minimum requirements as to tensile properties:

	Min tensile strength, lb per sq in.	Elongation in 2 in., per cent
Grade C	75,000	22½
Grade D	90,000	18

be used for the construction of seamless vessels for noncorrosive stationary service at temperatures ranging from —20 F up to 450 F, if designed with integral heads in accordance with Par. U-140 and with a maximum *S* factor of one fourth of the minimum tensile strength?

Reply: It is the opinion of the Committee that this material may be used for the construction of seamless vessels under the conditions set forth in the inquiry and these vessels may be stamped with the Code symbol, provided there are no stress raisers such as openings or stampings on the shell portion, and all outlet openings are located in the head portions where there is thickness available to reduce the calculated stress to one half or less of the maximum allowable stress. The impact test is not required for these vessels.

Inquiry: Are separately fired steam superheaters which are not an integral part of a boiler or are separated from a boiler by stop valves considered within the scope of the Power Boiler Code? If so, what are the Code requirements for such a superheater?

Reply: It is the opinion of the Committee that separately fired steam superheaters which are not integral with a boiler or are separated from a boiler by stop valves are fired pressure vessels and within the scope of the Power Boiler Code. Such superheaters shall meet Code requirements from the inlet flange to the outlet flange including all piping, valves, and safety devices required by the Code. In such an installation a stop valve at the outlet of the superheater is not required by the Code. Such superheaters shall be stamped with the Code symbol, design steam pressure and temperature, and square feet of heating surface.

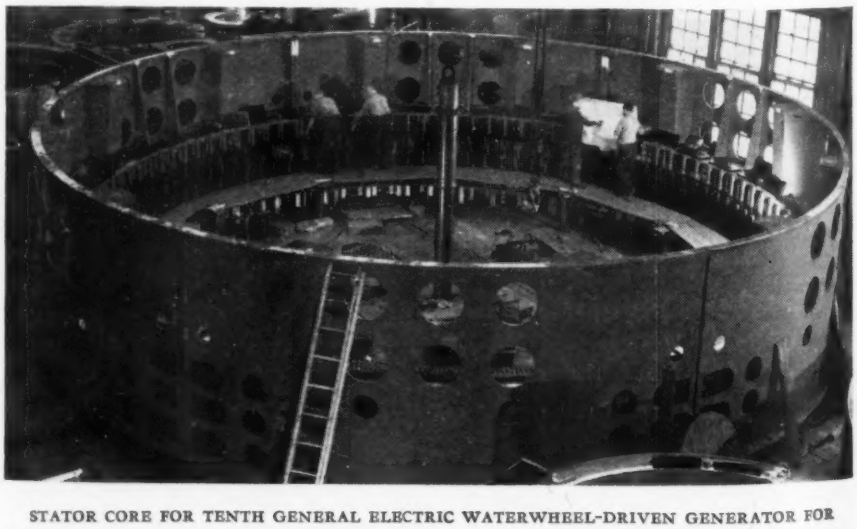
Where welded joints are used in place of flanged inlet and/or outlet connections, Code requirements shall begin or end at the weld where flanges, if used, would have been placed. Such attachment welds to connecting piping which are not exposed to high-temperature gases are not within the scope of the Code requirements.

CASE No. 992

(Interpretation of Pars. P-102(g and U-68(g)

Inquiry: The requirements of Pars. P-102(*g*) and U-68(*g*) do not allow retest if the first test fails to meet the requirements by more than 10 per cent. When all other tests meet the requirements of the Code, may a retest of the free-bend specimen be made even though the original test failed by more than 10 per cent?

Reply: Since failure of free-bend test specimens sometimes occurs because of permissible defects such as slag inclusions and porosity, it is the opinion of the Committee that the requirements of the first sentence of Pars. P-102(*g*) and U-68(*g*) may be modified as follows: That in the case of failure of a free-bend test specimen to meet the requirements in Pars. P-102(*f*) and U-68(*f*) by more than 10 per cent, retests may be made at the discretion of the inspector.



STATOR CORE FOR TENTH GENERAL ELECTRIC WATERWHEEL-DRIVEN GENERATOR FOR BONNEVILLE DAM NEARING COMPLETION

(Approximately 41 ft in diameter, this frame is believed to be the largest in the world.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Pirotechnia

THE PIROTECHNIA OF VANNOCCIO BIRINGUCCIO. Translated from the Italian with an introduction and notes. By Cyril Stanley Smith and Martha Teach Gnudi. Publication sponsored by the Seeley W. Mudd Memorial Fund. The American Institute of Mining and Metallurgical Engineers, New York, N. Y., 1942. Buckram, $7^3/_4 \times 10^1/_2$ in., 476 pp., illus., $5.

REVIEWED BY S. C. HOLLISTER[1]

MOST of us who have to deal with the working and forming of metals are prone to regard the art of metalworking and the science of metallurgy as developments of recent decades. The truth is that these branches of knowledge, which have undergone such rapid developments in our times, had their beginnings in antiquity, and for centuries were carried forward by the craftsmen and artists in metalworking. Not until the accumulated knowledge and the experiences of the artificer were written into books for others to study was it possible to systematize into a science the metallurgical practices. The first book having some real claim to comprehensiveness is therefore an important document in the train of developments in this field. This book is very rare, and if accessible would be unreadable by the majority of engineers in this country, because it is in Italian. It is of real moment therefore that there has just issued from the press of the American Institute of Mining and Metallurgical Engineers a scholarly translation of "Pirotechnia" by Biringuccio.

The author was born in Siena in 1480. He lived in turbulent times. He was a lad of twelve when Columbus discovered the New World. During his lifetime, Cortez invaded Mexico and Pizarro conquered Peru, both to fatten the coffers of Phillip II of Spain. But these happenings were far away. In Italy the Medici and the Borgias were busy with their intrigues and wars. Contemporaries of the author were Leonardo da Vinci, Michelangelo, Titian, Cellini—and Machiavelli.

In peacetime Biringuccio was engaged in minting coins and casting objects of art, and in war in producing cannon and balls that would violently burst. His knowledge of metalworking was firsthand. His writing is direct and clear and lacks the cloak of mystery so commonly shrouding the descriptions of processes set down in his day. This man, whose book did not appear until a year later, died in 1539, the year De Soto discovered Florida.

"Pirotechnia" consists of ten "books," the first four of which are devoted to smelting and the last six to metalworking and founding. Since the author was primarily a metalworker, he depended on information from others for his description of smelting methods. He has very little to say on mining methods and in this respect does not encroach upon the chief field of Agricola's "De re Metallica." In the "books" on metalworking, he goes into detail concerning the working of ferrous and nonferrous metals and into the casting of statues, bells, and cannon.

When one recalls the extent to which alchemy was hopefully believed in during Biringuccio's time, one is struck with the directness and realism of his writing. His approach to alchemy may be summed up in his statement, "many are quoted by the credulous, who advance the authority of hearsay in place of reasons for possible success or facts that can be demonstrated." His attitude toward the alchemists, however, was tolerant for he says, "I know that, if perchance some who are passionately devoted to this art should read my work, they would denounce me, accusing me of ignorance and presumption—and if I should hear them, I would patiently agree so as not to quarrel with them."

He recognizes gold as the most desirable of all metals. The more it is fired and worked, he says, the purer it becomes. "Nature with her own virtue has endowed gold, as a singular privilege, with power to comfort weakness of the heart and to introduce there joy and happiness, disposing the heart to magnanimity and generosity of works. Many learned men say that this power has been conceded to it by the benign influence of the sun and that for this reason it gives so much pleasure and benefit with its great powers—particularly to those who have great sacks and chests full of it."

The author discusses at some length the construction of furnaces for handling a variety of metals. His illustrations are clear and concise and together with the text give very clearly the methods employed in those days.

One very interesting section of the book is devoted to boring cannon. He shows drawings of several types of cutting heads on the boring bars and the manner in which the gun barrel was mounted on a movable carriage while the rotating boring bar was held at a fixed location.

The author discusses at length the preparation of sands and powders for casting. One chapter is devoted to the preparation of green-sand molds. Another chapter is devoted to advice "On How to Operate a Mint Honestly and With Profit."

Since it is necessary to make brick and crucibles for melting purposes, the author includes procedure for making lime and bricks and pottery and how to fire them. He also describes methods of making saltpeter and gunpowder and how they may be used to make fireworks and incendiary arrows and grenades.

The translation is a scholarly piece of work. Important but doubtful passages are annotated. Notes on contemporary references have been added to broaden the knowledge of the horizon of the author's time.

One cannot escape the atmosphere given to this work through the choice of typography, paper, and binding and through the reproduction of the woodcuts of the original volume. It reflects the care with which the translators and the publishers have joined to present this important work with thoroughness and accuracy. Moreover, it carries into a modern publication some of the art and charm of the early books.

[1] Dean, College of Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

Lubrication

LUBRICATION. By Arthur E. Norton. McGraw-Hill Book Co., Inc., New York, N. Y., 1942. Cloth, 6×9 in., 244 pp., 115 figs., $3.

REVIEWED BY S. J. NEEDS[2]

THIS book is intended to furnish a general introduction to the science of lubrication and to provide a classroom text for students of that subject. Recognizing the growing importance of bearings and their lubrication, recent editions of books on machine design contain chapters on bearings. "Lubrication,"

[2] Service Manager, Kingsbury Machine Works, Inc., Philadelphia, Pa. Mem. A.S.M.E.

however, is the first entire volume on that subject written primarily for classroom use and it fills a real need for such a textbook. Starting with an introductory chapter which defines bearings, friction, and lubricants, there follow chapters on fluid-film friction and viscosity, thin-film friction and oiliness, and the general properties of lubricants. These chapters give the student a general picture of the basic problems of lubrication and definitions of the factors involved. Several chapters are devoted to the application of the hydrodynamic theory to plane and journal bearings of finite and infinite widths. The effect of variable viscosity in the oil film is considered and the problem of thermal equilibrium of the bearing is discussed. Attention is given to bearing grooving, and some methods of introducing the lubricant into the bearing are described. The final chapter of the book comprises a brief discussion of ball, roller, and needle bearings.

The book gives a good introduction to the somewhat complex subject of bearing theory. The material is logically developed, and the text clearly written and illustrated by numerous problems. Usefulness of the book is by no means limited to the classroom. It should be found a valuable and interesting reference not only by the bearing designer but also by the engineering profession in general.

Empirical Equations and Nomography

EMPIRICAL EQUATIONS AND NOMOGRAPHY. By Dale S. Davis. McGraw-Hill Book Co., Inc., New York, N. Y., 1943. Cloth, 6 × 9 in., 200 pp., 70 figs., $2.50.

REVIEWED BY H. L. SEWARD[3]

THIS little book of 169 pages presents, in nice mathematical style, two subjects which in one sense are as far apart as possible—given the data, required the curve and formula; and given the formula, required the diagram—and yet in another sense are closely related in the experience of engineers. Part I is entitled "Empirical Equations" while Part II bears the ambitious and inclusive title, "Nomography."

The author gives ten familiar type expressions to aid in identifying plotted data, with suitable plotting suggestions to produce straight lines, and handy guiding devices to determine the necessary constants. A series of so-called "illustrations," numbered to correspond to the ten types, really are examples worked out in detail for each case and are illustrations in that they define the step-by-step mathematical procedures. Where none of the standard types satisfy because of being too cumbersome or laborious, there are ways of modifying the standard form and, if necessary, of creating a new form for the problem in hand. In the chapter on three variable correlation we approach the field of cartesian nomography and the series of "illustrations" continues. A splendid set of problems is offered at the end of each of the three chapters of Part I.

In Part II, Nomography, the author evidently feels that for the simple and limited nomograms here given, the determinant method of analysis is too difficult for the reader.

Having followed a pattern in Part I which seeks to identify the problem in hand with an established type, it is but natural that he fails to use determinants. The power and capacity of the determinant method is so well established in the devising of nomograms that it could have been included here and greatly strengthen the rather weak fifty pages devoted to Nomography. The book ends with a short chapter on special slide rules, some excellent miscellaneous problems, useful tables, and an overwhelming Bibliography. In format and style, the book is excellent. This book will be a useful adjunct in teaching a course in graphical methods where routine is emphasized. It makes a real contribution in Part I, Empirical Equations, but hardly scratches the surface in Part II, Nomography.

[3] Professor of Mechanical Engineering, Yale University, New Haven, Conn. Mem. A.S.M.E.

Books Received in Library

AEROSPHERE 1942, edited by G. D. Angle. Aircraft Publications, New York, N. Y., 1942. Cloth, 8½ × 12 in., 1156 pp., paged in sections, illus., diagrams, tables, $12.50. This edition of this useful reference work provides a detailed survey of aircraft throughout the world, with special emphasis on military aviation. Under the topics, The U. S. War Effort, Modern Aircraft of the World, Modern Aircraft Engines of the World, Aircraft Armament, Aircraft Statistics, Buyer's Guide, the entire industry is covered. Each airplane and each engine are described and illustrated by photograph or drawing. The book will answer almost any question in its field.

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS, prepared by A.S.T.M. Committee D-2; Methods of Testing, Specifications, Definitions, Charts, and Tables. American Society for Testing Materials, Philadelphia, Pa., October, 1942. Paper, 6 × 9 in., 442 pp., illus., diagrams, $2.25. The 1942 report of the committee on petroleum products and lubricants, the standard and tentative methods of test, and specifications pertaining to petroleum are brought together in convenient form.

A.S.T.M. STANDARDS ON TEXTILE MATERIALS, prepared by A.S.T.M. Committee D-13 on Textile Materials; Specifications, Tolerances, Methods of Testing, Definitions and Terms. American Society for Testing Materials, Philadelphia, Pa., October, 1942. Paper, 6 × 9 in., 408 pp., illus., diagrams, charts, tables, $2.25. This pamphlet contains the definitions and terms, methods of testing, and specifications for textiles and related materials at present in force. Seventy-three specifications are given for cotton goods, glass fabrics, jute, rayon, silk, and wool. In addition to specifications, the publication contains photomicrographs of the common textile fibers, a yarn number conversion table, and other useful information.

AIRCRAFT LOFTING AND TEMPLATE LAYOUT With Descriptive Geometry. By H. Thrasher. Aviation Press, San Francisco, Calif., 1942. Stiff paper, 7½ × 10 in., 212 pp., illus., diagrams, charts, tables, spiral binding, $3.50. This book is intended for beginners, primarily those entering the aircraft industry, but also useful to those entering shipbuilding. The first section deals with descriptive geometry. In section two template theory and practice are discussed. Section three is devoted to lofting and a final section gives some useful general information.

AIRPLANE DESIGN MANUAL. By F. K. Teichmann. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, 6 × 9½ in., 440 pp., illus., diagrams, charts, tables, $4.50. This volume outlines an orderly form of procedure in design, covering such subjects as preliminary weight estimating, the three-view and the balance diagram. In addition, information is given on wing design, fuselage design, power plant, control, instruments, etc., sufficient to enable the beginner to carry out the design of a new machine, and to supplement works on aerodynamics and structures.

ALFRED NOBEL, Dynamite King—Architect of Peace. By H. E. Pauli. L. B. Fischer, New York, N. Y., 1942. Cloth, 5½ × 8½ in., 325 pp., $3. This interesting biography of the inventor gives a detailed account of his life. His work in originating high explosives, through which he accumulated a vast fortune, his interest in world pacifism, and his endeavors to promote peace by founding the Nobel prizes are described in full. A sympathetic account of a strange genius.

AMERICAN DIESEL ENGINES, Their Operation and Repair. By E. F. Goad. Harper & Brothers, New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 313 pp., illus., diagrams, tables, $2.75. Intended as an introductory text for vocational classes, this textbook offers an excellent account of the principles of the Diesel engine and of its general design and construction, with practical advice on its operation, maintenance, and repair. The book is based on long teaching experience.

AMERICA FLEDGES WINGS, the History of the Daniel Guggenheim Fund for the Promotion of Aeronautics. By R. M. Cleveland, with a foreword by R. A. Millikan. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, 6 × 9½ in., 224 pp., illus., diagrams, charts, maps, tables, $2.50. The story of this fund and the great part it played in fostering the development of aeronautical achievement in America is told in detail in this interesting volume.

ANNUAL REPORT ON THE PROGRESS OF RUBBER TECHNOLOGY, vol. 5, 1941. Published by W. Heffer & Sons, Ltd., Cambridge, England, for the Institution of the Rubber Industry, London, S. W. 1, England, 1942. Paper, 7½ × 9½ in., 145 pp., 10s 6d to nonmembers, 2s 6d to members. These annual reports by groups of experts afford a convenient means for keeping abreast of developments in the field of

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

rubber. Every aspect of the cultivation, properties, and uses of rubber is discussed, and each report is accompanied by an extensive bibliography. A name index is also provided.

APPLIED NUCLEAR PHYSICS. By E. Pollard and W. L. Davidson, Jr. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, 6 × 9½ in., 249 pp., illus., diagrams, charts, tables, $3. The technical aspect of the subject is emphasized in this book, which aims to present the essential facts and methods of artificial radioactivity and transmutation in a way that will be of service to chemists, engineers, and others who use the products of nuclear physics in their own spheres of work. An unusually readable account of the subject is provided, which should prove an excellent textbook.

MAN BEHIND THE FLIGHT. By A. Jordanoff. Harper & Brothers, New York, N. Y., 1942. Cloth, 7 × 10 in., 276 pp., illus., diagrams, charts, tables, $3.50. This book presents some information on mechanical drawing, elementary electricity and hydraulics, mechanics and physics, accompanied by a brief outline of airplane history. It is offered as a ground course for aviation mechanics and airmen.

MECHANICAL DRAWING. By E. Kenison and J. McKinney, revised by T. C. Plumridge. American Technical Society, Chicago, Ill., 1943. Cloth, 5½ × 8½ in., 330 pp., illus., diagrams, charts, tables, $2. This textbook offers a practical course, adapted for class use or home study.

MECHANICAL TESTING OF METALS AND ALLOYS. By P. F. Foster. Third edition. Sir Isaac Pitman & Sons, London, England; Pitman Publishing Corporation, New York, N. Y., 1942. Cloth, 5½ × 8½ in., 317 pp., illus., diagrams, charts, tables, cloth, 18s or $5. Descriptions of modern testing equipment are coupled with its mode of use and combined with the theory underlying current developments in the testing of metals in a very practical way. The book should be useful for reference.

PLASTICS CATALOG 1943, an Encyclopedia of the Plastics Industries. Plastics Catalogue Corporation, New York, N. Y., also 221 N. La Salle St., Chicago, Ill. Fabrikoid, 9 × 12½ in., 864 pp., illus., diagrams, charts, tables, $5. This large volume will be found most useful by all users of plastics. A combination of technical encyclopedia and trade directory, it contains authoritative articles on properties of the various plastics, on plasticizers and solvents, on manufacture, machinery, molding, fabricating, laminates, coatings, synthetic fiber, synthetic rubber, etc. The directory section covers the manufacturers of plant equipment and includes a bibliography, a glossary, an index of molders' marks, and a complete list of makers.

PRINCIPLES OF AIRCRAFT ENGINES. By B. A. Shields. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 5½ × 8½ in., 378 pp., illus., diagrams, charts, tables, $1.88. This text is intended for preflight students of high-school age and is concerned with engines, their function and operation, and with propellers and engine instruments.

PROCESS PRACTICES IN THE AIRCRAFT INDUSTRY. By F. D. Klein, Jr. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in., 266 pp., illus., diagrams, charts, tables, $2.75. The processes, methods, and materials currently used in the aircraft industry are discussed in this book, which is intended as a reference and instruction book for workers in that field. The procurement of raw materials, their marking for identification, the metals, fabrics, and organic finishes used are listed in full and described briefly. Methods of processing are discussed at some length. A great deal of information is compressed into a small book.

PSYCHOLOGY FOR BUSINESS AND INDUSTRY. By H. Moore. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9½ in.; 526 pp., illus., diagrams, charts, tables, $4. This text is devoted especially to those aspects of psychology which have been shown to be of value in the business and industrial worlds. The practical personnel problems of testing applicants for positions, appraising employees, training, promotion, accidents, fatigue, etc., are discussed, together with the psychological factors in selling. The new edition has been carefully revised.

QUESTIONS AND ANSWERS FOR MARINE ENGINEERS, BOOK I, BOILERS, compiled by H. C. Dinger. *Marine Engineering and Shipping Review* (Simmons-Boardman Publishing Corp.), New York, N. Y., 1942. Paper, 5 × 8 in., 168 pp., tables, $1. During the last twelve years the *Marine Engineering and Shipping Review* has published answers to readers' questions. This booklet contains a collection of those on the operation of marine boilers and on boiler-room equipment, which answer many problems that arise.

QUESTIONS AND ANSWERS FOR MARINE ENGINEERS, BOOK III—AUXILIARIES. *Marine Engineering and Shipping Review* published by Simmons-Boardman Publishing Corporation, New York, N. Y., 1943. Paper, 5 × 8 in., 139 pp., diagrams, tables, $1. This little manual contains material selected from the Questions and Answers department of *Marine Engineering and Shipping Review*. The questions refer to practical difficulties encountered in operating pumps, condensers, refrigerating equipment, evaporators, and other auxiliary equipment of ships.

RAILWAY ENGINEERING AND MAINTENANCE CYCLOPEDIA, fifth edition, 1942. Edited by E. T. Howson and others. Simmons-Boardman Publishing Corporation, Chicago, Ill., and New York, N. Y. Fabricoid, 8 × 12 in., 1224 pp., illus., diagrams, charts, maps, tables, $5. The Encyclopedia is designed to cover thoroughly the best practice of American railways with regard to the materials, devices, and products used in the construction and maintenance of the fixed properties. Sections are devoted to Track, Bridges, Water Service, Signals, and General Topics. Each technical discussion is supplemented by material prepared by manufacturers, discussing their products in detail. The new edition has been thoroughly revised and partly rewritten.

READING AS A VISUAL TASK. By M. Luckiesh and F. K. Moss. D. Van Nostrand Co., Inc., New York, N. Y., 1942. Cloth, 5½ × 8½ in., 428 pp., illus., diagrams, charts, tables, $5. Describes the work of the authors in endeavoring to make a scientific analysis of the visual task of reading. The criteria of readability which have been developed and the devices and techniques which can be used to measure readability are discussed and certain conclusions drawn. The book is a pioneer effort in a relatively unexplored field. There is a bibliography.

SCIENCE IN PROGRESS. By H. Shapley, E. Hubble, H. A. Bethe, V. K. Zworykin, P. W. Bridgman, L. S. Marks, J. Franck, J. G. Kirkwood, P. H. Long, and H. Mark; edited by G. A. Baitsell. Third series. Yale University Press, New Haven, Conn.; Humphrey Milford, Oxford University Press, London, England, 1942. Cloth, 6 × 9½ in., 322 pp., illus., diagrams, charts, tables, $3. Contains ten lectures by distinguished scientists who discuss the results of recent research work in various scientific fields. The subjects considered in this volume include galaxies, the expanding universe, energy production in the stars, image formation by electrons, recent work in high pressures, power generation, photosynthesis, the structure of liquids, sulfanilamide and synthetic rubber.

SCIENCE OF MECHANICS. By E. Mach, translated from the German by T. J. McCormack. Open Court Publishing Co., La Salle, Ill., and London, England, 1942. Cloth, 5½ × 8 in., 635 pp., illus., diagrams, tables, $3.50. The new edition of this classic makes available again a work that has been out of print for more than a decade. It has been revised according to the ninth German edition, and the alterations and additions formerly printed as appendixes and in a supplementary volume have been incorporated in the text, with great improvement in readability.

SEVEN-PLACE VALUES OF TRIGONOMETRIC FUNCTIONS for Every Thousandth of a Degree, compiled by Dr. J. Peters. D. Van Nostrand Co., Inc., New York, N. Y., 1942. Cloth, 7 × 9½ in., no pagination given, tables, $7.50. These tables are admirably suited for large-scale computations with calculating machines. Tables are provided for sines, cosines, tangents, and cotangents. Supplementary tables are given for converting minutes and seconds into decimal parts of degrees, and vice versa, and for converting degrees to time and time to degrees.

THEORY AND PRACTICE OF HEAT ENGINES. By D. A. Wrangham. The Macmillan Co., New York, N. Y., University Press, Cambridge, England, 1942. Cloth, 7 × 10 in., 756 pp., illus., diagrams, charts, tables, $10.50. This is a general textbook, which provides an introduction to the various sections of this large subject. Air compressors and motors, reciprocating steam engines, steam condensers, steam turbines, gas, gasoline and oil engines, steam boilers, refrigeration, combustion, etc., are discussed with the aid of excellent diagrams.

TOOL DESIGN. (Rochester Technical Series.) By C. Donaldson and G. H. LeCain. Harper & Brothers, New York, N. Y., and London, England, 1943. Cloth, 6 × 9½ in., 443 pp., illus., diagrams, charts, tables, $3.75. This textbook presents the general methods of tool design in a practical way, with many applications of the principles to practical problems. The design of punches, dies, gages, jigs, fixtures, and cams is discussed, as well as the tooling of automatic screw machines and turret lathes.

TOOL DESIGN AND TOOL ENGINEERING. By J. G. Jergens. John G. Jergens, Cleveland, Ohio, 1942. Paper, 9 × 11½ in., 106 pp., diagrams, tables, $2. A collection of articles, drawings, and tables of interest to tool designers and engineers. Includes many examples of clamps, cams, tools, fixtures, etc.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Production for Victory to Be Featured at A.S.M.E. Spring Meeting

Rock Island Arsenal to Co-Operate at Davenport, Iowa, April 26–28

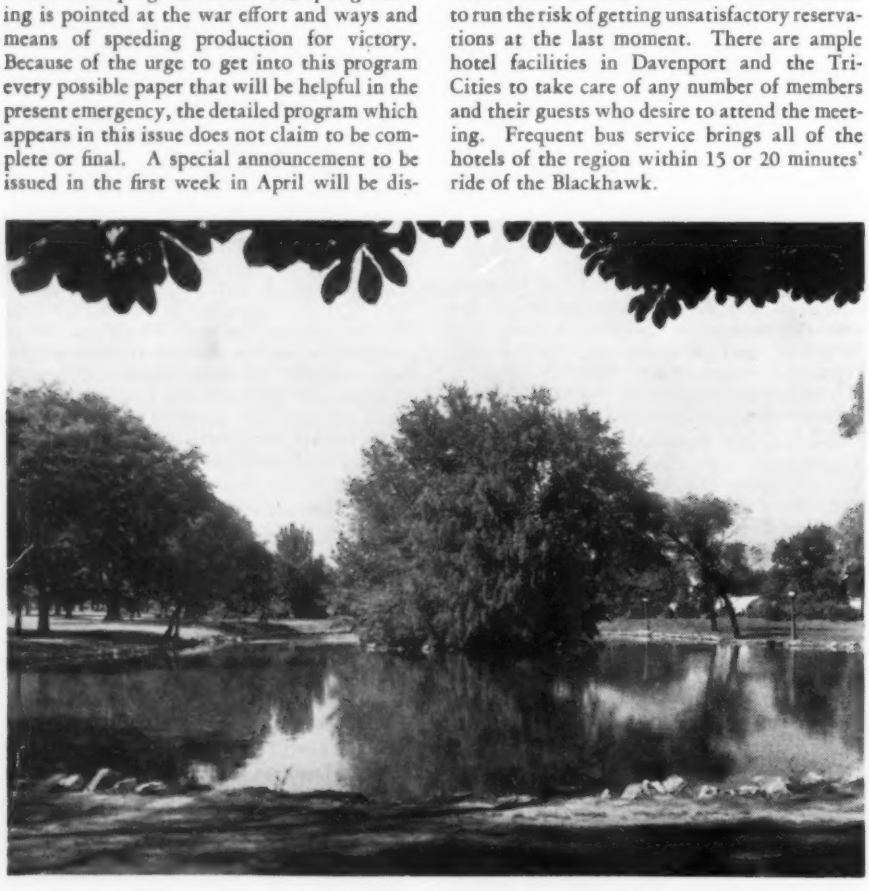
ROCK Island Arsenal is co-operating with The American Society of Mechanical Engineers in its program for the Spring Meeting to be held at Davenport, Iowa, April 26–28, at the Blackhawk Hotel. For the past month the question of how the Society might be able to co-operate with the Arsenal in solving some of its production problems to speed up the war effort and a number of interesting and important projects have been under consideration. The details as to how these should be handled are not yet sufficiently complete to make public announcement.

Special Announcement to Be Issued Early in April

The entire program for the 1943 Spring Meeting is pointed at the war effort and ways and means of speeding production for victory. Because of the urge to get into this program every possible paper that will be helpful in the present emergency, the detailed program which appears in this issue does not claim to be complete or final. A special announcement to be issued in the first week in April will be distributed to the members in the midwestern states. The announcement will be sent to the secretaries of each Local Section outside of that area so that members anywhere can get one promptly. However, if members at a distance of more than five hundred miles from Davenport expect to attend the meeting, additional information may be sent to them as it is issued, provided they let Headquarters know of their interest in the meeting.

Make Reservations Now

Hotel reservations should be made promptly. If there is any doubt about being able to attend the meeting, it is safer to make the hotel reservation and cancel it at the last moment than to run the risk of getting unsatisfactory reservations at the last moment. There are ample hotel facilities in Davenport and the Tri-Cities to take care of any number of members and their guests who desire to attend the meeting. Frequent bus service brings all of the hotels of the region within 15 or 20 minutes' ride of the Blackhawk.



LAGOON IN VANDERVEER PARK, DAVENPORT

Make Reservations for Rooms Early!

Hotel Blackhawk, Headquarters A.S.M.E. Spring Meeting

MEMBERS of the A.S.M.E. are urged to make their hotel reservations just as early as possible for the Spring Meeting of the Society to be held in Davenport, Iowa, April 26–28. It is extremely desirable that such reservations be in not later than April 10. Rooms may always be canceled but rooms cannot be picked up at the last moment. The Blackhawk Company which operates the headquarters hotel also manages two others.

Glass Gages a Timely Subject

To judge from the animated discussion which followed the presentation of a paper on glass for precision gages by Col. H. B. Hambleton, chief of the Gage Section, U. S. Ordnance Department, at a meeting of the Metropolitan Section on March 9, the subject is of enormous interest and novelty. Colonel Hambleton is presenting a paper on the same subject at the Davenport meeting. When he was asked if the Davenport paper would be a repetition of the Metropolitan Section paper, which is printed in this issue, pages 274–276, he replied that the development of glass gages is moving so rapidly that he would have much additional material to present by the end of April. No production engineer will want to miss Colonel Hambleton's paper.

On the same program with Colonel Hambleton, Col. Crosby Field, Assistant Director of Safety, Ordnance Department, will speak on "Safety in Ordnance Practices."

Rifle Broaching to Be Described

The broaching of caliber .30 rifle barrels will be described by an officer from the Rock Island Arsenal at another session sponsored by the Production Engineering Division. A description of aircraft engines on the production line will be presented at this same session by H. E. Linsley, of the Wright Aeronautical Corporation. Motion-picture films will dramatize Mr. Linsley's presentation.

Official U. S. Navy Photo

"WAVES" ON PARADE IN NEW YORK

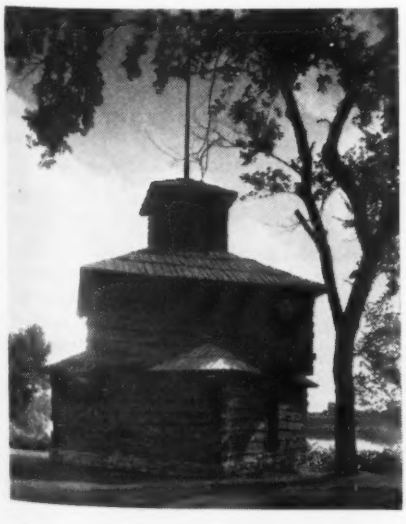
(They will relieve Navy personnel from many tasks and release them for the fighting forces. At the Spring Meeting of the A.S.M.E., Davenport, Iowa, April 26–28, there will be papers on the part women are playing in industry to relieve the manpower shortage.)

Engineering and Medicine on Technical Program

How engineering benefits the medical profession will be discussed at the opening session on Monday morning when a paper presenting an engineering discussion of the desiccation of human blood plasma will be offered. Counterbalancing this excursion of an engineer into the field of medicine, Dr. Arthur Steindler, eminent orthopedist, will address the Management Division on what biokinetics has to offer industry.

Under the supervision of the Management Division and the Committee on Education and Training for the Industries, Industrial Training for the War Effort and the Conservation of Manpower will be discussed at parallel sessions. The use of coal and lignite in the war effort and power maintenance problems will be presented in papers sponsored by the Fuels Division.

On Tuesday the Director of Civilian Personnel and Training of the War Department will speak on Manpower Utilization, and the Problem of the Small Plant in War Contracts will be discussed by a government official in charge of that work. Aviation will have two sessions on Tuesday covering the War Training Program in Colleges and certain phases of manufacturing methods as well as the future of air transport. The luncheon on Tuesday will be addressed by Major Nathaniel F. Silsbee, U.S.A., of the Bureau of Public Relations of the War Department, whose paper, "Airplanes Fit to Fight," published in MECHANICAL ENGINEERING in December, pages 847–852, made such a favorable impression.



FORT ARMSTRONG ON ARSENAL ISLAND, DAVENPORT

Women in Industry will be discussed by the Director of Foreman Training at Rock Island Arsenal as well as by those engaged in the direction of training of women for various industrial concerns.

President Coes to Speak at Dinner

The dinner on Tuesday evening will be addressed by Harold V. Coes, President of the Society, on the subject "What Management Is Contributing to the War Effort." Many members will be pleased to learn that there will be another opportunity to see the Sikorsky helicopter colored motion-picture film which was one of the features of the Annual Meeting last December. On Wednesday there will be a third session of the Aviation Division plus a joint meeting with the Wood Industries Division on the use of plywood in aircraft. The Wood Industries Division is developing a substantial program which will take the form of its national meeting as a division although incorporated with the program of the Spring Meeting of the Society.

There are no entertainment events planned for this meeting but the social side will be provided for in general luncheon meetings on each day and a dinner meeting on Monday and Tuesday.

A.S.M.E. Spring Meeting Program

Davenport, Iowa, April 26–28, 1943

Headquarters, Hotel Blackhawk

MONDAY, APRIL 26

9:30 a.m.

Meeting of Council

General Session

An Engineering Discussion of the Desiccation of Human Blood Plasma, by D. C. Pfeiffer, Industrial Engineer, Dallas Power and Light Co., Dallas, Texas

2:00 p.m.

Industrial Training and the War Effort

(Committee on Education and Training)

Training Employees for the War and After, by R. O. Johnson, director of training, International Harvester Co., Moline, Ill.

Training of Supervisors for War Production, by James Shevlin, director of training, John Deere & Co., Moline, Ill.

The Services of T.W.I., by A. E. Peterson, Training Within Industry, War Manpower Commission, Chicago, Ill.

Fuels—I

Lignite—Influence of Storage Conditions Upon Size Degradation, Size Stability, and Friability, by Carl J. Eckhardt, Jr., and C. W. Yates, University of Texas, Austin, Texas

Iowa Coals in the National Emergency, by H. L. Olin, professor of chemical engineering, University of Iowa, Iowa City, Iowa

4:00 p.m.

Sound Motion Pictures

(Management Division)

From Industrial Engineering Laboratory University of Iowa:

(Program continued on following page)

COL. H. B. HAMBLETON, CHIEF OF GAGE SECTION, ORDNANCE DEPARTMENT, SHOWING A GLASS PLUG GAGE TO THORNTON LEWIS (CENTER) AND BRIG. GEN. M. F. SAFFORD (RIGHT)

(Colonel Hambleton's paper, "Glass for Precision Gages," pages 274–276, will be supplemented by the most recent information on the subject in a paper he will present at the 1943 A.S.M.E. Spring Meeting, Davenport, Iowa, April 26–28.)

Monday (*Continued*)

Motion Study Applications
Motion Study in Action

6:30 p.m. Dinner

Plant Perpetuation, by J. C. Hobbs, Engineering Consultant, U. S. Navy, Washington, D. C.

8:00 p.m.

Operation of Industrial Power Plants During War

Operation of Industrial Power Plants Under Wartime Conditions, by G. H. Suhs, Sorg Paper Co., Middleton, Ohio

Colored Movies on Fuel Burning Operation and Maintenance During Wartime, shown by Otto de Lorenzi, Combustion Engineering Co., New York

Government Training Services

(*Committee on Education and Training*)

Vocational Training for War Production, by L. S. Hawkins, director of Vocational Training for War Production Workers, U. S. Office of Education, Washington, D. C.

College Level War Training, by C. W. Beese, professor of industrial engineering, and director of E.S.M.W.T., Purdue University, Lafayette, Ind.

Monday (*Continued*)

The Training Program of the War Manpower Commission, by Philip S. Van Wyck, assistant director, Bureau of Training, War Manpower Commission, Washington, D. C.

Motion Study for Conservation of Manpower

(*Management Division*)

What Has Biokinetics to Offer Industry, by Arthur Steindler, professor and head of orthopedic surgery, College of Medicine, University of Iowa, Iowa City, Iowa

Motion Study for Factory Workers, by William J. Biehl, supervisor of methods development, Libby, McNeill & Libby, Chicago, Ill.

Farm Work Simplification, by Marvin E. Mundel, assistant professor of industrial engineering, Purdue University, Lafayette, Ind.

Power

Caustic Washing of Turbine Blades Under Load, by W. L. Webb and R. G. Call, American Gas & Electric Co.

The Chemical Removal of Scale From Heat-Exchange Equipment, by F. M. Alquist, resident chemist, C. H. Groom, chemist, Dow Chemical Co., Midland, Mich.; and

Monday (*Continued*)

Guy F. Williams, development engineering, Dowell, Inc., Tulsa, Okla.

TUESDAY, APRIL 27

9:30 a.m.

Aviation—I

Work of Civil Aeronautics Administration in the War Effort. John P. Morris, director of War Training Program in Colleges, C.A.A., Washington, D. C.

C.A.A. War Training Program in Colleges From a Teacher's Standpoint, by E. C. Lundquist, University of Iowa, Iowa City, Iowa

Manpower Utilization

(*Management Division*)

A Management Check List for Manpower Utilization, by W. H. Kushnick, director of civilian personnel and training, War Department, Washington, D. C.

Small Plants and War Contracts, by George J. Huebner, chief of tooling section, Small War Plant Division, Washington, D. C.

Fuels—II

Steam-Air Jets for Producing Furnace Turbulence, by R. B. Engdahl, Battelle Memorial Institute, Columbus, Ohio

Direct-Fired High-Temperature Carbon-Steel Air Heaters, by R. M. Rush, Dravo Corporation, Pittsburgh, Pa.

Wood Industries—I

Delamination Tests on Plywood and a Proposed Specification, by C. W. Muhlenbruch, assistant professor of civil engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

Observations on Density and Shrinkage of Ponderosa Pine, by Robert A. Cockrell, Forest Products Laboratory, Madison, Wis.

12:30 p.m.

Aviation Luncheon

Talk by Major Nathaniel F. Silsbee, U.S.A., Air Information Secretary, News Division, Bureau of Public Relations, War Department, Washington, D. C.

2:00 p.m.

Aviation—II

The Future of Air Transport, by W. W. Davies, research engineer, United Airlines Transport Corporation, Municipal Airport, Chicago, Ill.

The Modern Methods in Aircraft Welding, by N. F. Ward, senior methods engineer, Beech Aircraft Corporation, Wichita, Kansas

Women—the Answer to Manpower Shortage

Selection and Employment of Women, by B. I. Beverly, director of health and personnel, Republic Drill and Tool Co., Chicago, Ill.

Training and Supervision of Women, by W. F. Sherman, director of foreman training, Rock Island Arsenal, Rock Island, Ill.

Tube Expanding

(*Power Division and Research Committee*)

Theory of the Expansion of Boiler and Condenser Tube Joints Through Rolling, by A. Nadai, Consulting M.E., Westinghouse Research Laboratory, E. Pittsburgh, Pa.

(*Program continued on following page*)

Tuesday (*Continued*)

The Hyperbolic Sine Relation Between Creep Rate and Stress at a Constant Temperature, by P. G. McVetty, Research engineer, Westinghouse Electric & Manufacturing Co., E. Pittsburgh, Pa.

6:30 p.m.

Dinner

What Management Is Contributing to the War Effort, by H. V. Coes, President, A.S.M.E.

The Sikorsky Helicopter (colored films with descriptive comment)

WEDNESDAY, APRIL 28

9:30 a.m.

Heat-Transfer—I

Heat-Transfer and Pressure Drop Annuli, by Elmer S. Davis, Alco Products Division, American Locomotive Co., New York, N. Y.

Heat-Transfer to a Fluid Flowing Periodically at Low Frequencies in a Vertical Tube, by R. C. Martinelli, L. M. K. Boelter, E. B. Weinberg, and S. Yakahi, University of Calif., Berkeley, Calif.

Production Engineering—Aviation

Aircraft Engines on the Production Line (with films), by H. E. Linsley, technical adviser, public relations, Wright Aeronautical Corporation, Paterson, N. J.

Broaching of Rifling in Caliber .30 Machine-Gun Barrels, Rock Island Arsenal

Panel Discussion on Storage of Coal

(*Fuels-Power Divisions*)

Wood Industries—II

Plastic Developments From Redwood, by Harry F. Lewis, Institute of Paper Chemistry, Appleton, Wis.

2:00 p.m.

Heat-Transfer—II

Rate of Ice Formation, by A. L. London and R. A. Seban, Stanford University, Calif.

A.S.M.E. Calendar

of Coming Meetings

April 26–28, 1943
Spring Meeting
Davenport, Iowa

June 14–16, 1943
Semi-Annual Meeting
Los Angeles, Calif.

June 14–16, 1943
Oil and Gas Power Division
Baltimore, Md.

July 2–3, 1943
Applied Mechanics Division
Carnegie Institute of Technology
Pittsburgh, Pa.

October 26–29, 1943
Joint Meetng of A.I.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

(*For coming meetings of other organizations see page 34 of the advertising section of this issue*)

Wednesday (*Continued*)

Performance and Selection of Mechanical Draft Cooling Towers, by Joseph Lichtenstein, Foster Wheeler Corporation, New York

Ordnance Practices

(*Production Engineering Division*)

Glass Gages, by H. B. Hambleton, Colonel, Ordnance Department, Chief, Gage Section, Office of the Chief of Ordnance, Washington, D. C.

Safety in Army Ordnance Establishments, by Crosby Field, Colonel, Ordnance Department, U.S.A., assistant director of safety, Chicago, Ill.

Wood Industries—Aviation

Plywood Use in Aircraft, by Robert W. Hess, Curtiss Wright Corporation, Buffalo, N. Y.

Flexible Pressure in Veneer and Plywood Work, by Thomas D. Perry, Resinous Products Co., Philadelphia, Pa.

Actions of A.S.M.E. Executive Committee

At Meeting in Society Headquarters on February 26

A meeting of the Executive Committee of The American Society of Mechanical Engineers was held at the headquarters of the Society on February 26 with President Harold V. Coes presiding. There were present George E. Hulse, C. B. Peck, and A. R. Stevenson, Jr., of the committee; W. A. Carter (Professional Divisions); A. R. Mumford (Local Sections); C. E. Davies, secretary; and Ernest Hartford, executive assistant secretary. G. L. Knight (Finance) attended during the afternoon session and Col. James L. Walsh was present during the discussion of the War Production Committee problems. Members of the executive committees of the Metals Engineering and Management Divisions met with the Executive Committee at the afternoon session.

Representative on U.E.T.

G. L. Knight was appointed A.S.M.E. representative on the United Engineering Trustees, Inc., to fill the unexpired term of Walter Kidde, deceased.

War Production Clinics

On recommendation of the Committee on Local Sections it was voted to continue the production clinics and to leave the details of operation to the Committee on Local Sections.

Division on Instruments and Regulators

The appointment of Ed S. Smith as chairman of the Industrial Instruments and Regulators Division was confirmed and that of J. C. Peters as secretary of the Division was approved.

Publicity

The Executive Assistant Secretary was authorized to contract with George A. Hastings, who handled the publicity of the A.S.M.E. 1942 Annual Meeting, to act as public relations counsel for the Society for the remainder of the current fiscal year.

Funk to Head A.I.E.E.

It was reported that Nevin E. Funk, chairman of the Committee on Meetings and Program, had been nominated to the presidency of the American Institute of Electrical Engineers. The President was asked to write a letter of congratulation to Mr. Funk and express appreciation of this recognition of his leadership in the engineering profession.

Death of H. H. Vaughan

The following resolution on the death of Henry H. Vaughan, adopted by the A.S.M.E. Boiler Code Committee, was recorded:

WHEREAS, the Boiler Code Committee of The American Society of Mechanical Engineers has learned with deep regret of the death on December 11, 1942, of Henry Hague Vaughan, and

WHEREAS, Henry Hague Vaughan was for many years an active and valuable member of this Committee and was, upon his retirement, unanimously elected an honorary member, and

WHEREAS, he had by long, outstanding, and constructive engineering work in the railroad and locomotive-building field brought to the Committee his talent and experience of inestimable value, and

WHEREAS, his sound judgment, co-operative spirit, and helpfulness endeared him to all former and present members of this Committee, now be it

Resolved, that the members of this Committee share with the engineering profession of Canada full appreciation of the valuable work contributed by Mr. Vaughan during World War I, and which he had continued to contribute up to the time of his death, and be it further

Resolved, that a copy of these resolutions be spread upon the minutes of this meeting and that a copy thereof be presented to the members of Mr. Vaughan's family, to the Council of The Engineering Institute of Canada, and to the Council of the Society.

War Production Committee

Program. At its meeting on October 11, 1942, the Executive Committee of the Council requested the War Production Committee to develop a forward-looking program of co-operation with war agencies. The Chairman of the Committee, Col. James L. Walsh, reported that progress is being made in developing a definite program of specific problems in the solution of which the War Production Committee can be of substantial assistance to the Ordnance Department of the U. S. Army. The Secretary reported that during the past three months Colonel Walsh had delivered over twenty addresses to the Local Sections and Student Branches of the Society and had been the principal speaker at several Production Clinics. In view of his widespread contacts with the Society's work and with national-defense problems, his experience would be most useful to the program-making agencies of the Society.

Accordingly, the Executive Committee of the Council requested the Secretary to inform the committees interested of Colonel Walsh's willingness to be of assistance in their program-making activities and to urge them to make full use of his services.

A.S.M.E. Staff

The period of C. B. Le Page's services in Washington, on simplification work, was extended three months from March 15, 1943.

President's Page

Some Engineering Contributions to the War

TO a considerable extent this is an engineers' and scientists' war. A few paranoiacs have plunged us into it, but it is due in large measure to the number, training, experience, and skill of the engineers that we have been able to meet the challenge with augmented peacetime facilities.

This has been accomplished largely through skill in design, in specification preparation, in selection and layout of productive equipment; in tooling, in jigs and fixtures; also in adopting semi- or in-line production methods to the products for fighting the war, whether for small fire-control or aviation instruments or for huge tanks and bombers.

I remember talking with a man in the club car of a train just after the President had stated he wanted 60,000 planes of all kinds in 1942. This man said, "That is fantastic, ridiculous, and impossible." I replied, "Not fantastic. If he tells us what he wants, gives the right of way to the machine tools and materials, partially freezes the designs, and bars labor agitation and strikes, he will then get his planes." As a matter of fact we produced 49,000 planes in 1942, many of them of considerably larger size than was contemplated in the original schedule, so in all probability, allowing for this, the President received very nearly the equivalent of the 60,000 planes called for.

To request that 60,000 planes be produced in a year does not produce them, as we know; that is just a requisition for production. These demands, however, set in motion such gigantic engineering projects as, for example, multiplying several fold our aluminum and magnesium production facilities, plane engines, instruments, plane parts, and plane-assembly facilities. You can readily appreciate the mass of engineering calculations, sketches, drawings, and specifications that were required before these facilities could be constructed.

Think of the improvisations that were made to save critical materials, to replace unavailable productive facilities, and to overcome unforeseen contingencies, such as developing single-purpose engine drilling machines from portable bench drills, changing structural designs from steel to reinforced concrete or timber, relocation of buildings on the site, and the like. This affords some comprehension at least of the magnitude of the problems that confronted the engineers aside from the stupendous volume of details that had to be meticulously fitted together.

To bring the picture into closer focus consider what this plane production which the engineers have provided for means. At the end of 1943 the total horsepower of the engines required for the planes to be produced in the United States may be about 350,000,000 hp. Now that is like an astronomer's unit of measurement, the light-year. Unless it is related to something one can compare it with, the mind does not take it in. This 350,000,000 plane-engine horsepower is probably from one and a half to two times the installed central-station capacity of the world and perhaps six or seven times the combined horsepower of the British and the United States Navies.

At Chicago the Chrysler Corporation will soon have in operation the world's largest factory producing plane engines, an engineering feat which in many respects surpasses the Boulder Dam hydroelectric project.

This is what engineering has enabled management to do in an incredibly short time to support the armed forces of the United Nations. It is truly a marvelous performance on the part of the engineers.

(*Signed*) H. V. COES, *President, A.S.M.E.*

Among the Local Sections

Engineers of Northern Connecticut Hold War Production Conference on Jan. 21

Panel Discussions Feature Subjects of Interest to Management, Engineers, Production Men, and Foremen

DRAWING an attendance of more than 1000 engineers, management executives, production men, and foremen, the War Production Conference held in Hartford, Conn., on the afternoon and evening of Jan. 21, featured discussions and forums on critical phases of production at which leading engineers and experts interchanged proved ideas and experiences in order to help the country obtain the maximum production while practicing the ultimate economy in materials, in man-hours, and in the use of facilities. L. C. Smith, chairman of the A.S.M.E. Hartford Section, one of the sponsoring organizations, was general chairman of the Conference.

Governor of Connecticut Speaks

Gov. Raymond E. Baldwin, as principal speaker at the banquet, emphasized the state's determination to relieve the fuel and labor situations through facing both problems "in the best tradition of Connecticut, with energy, courage, and faith." Capt. A. K. Atkins, U.S.N., inspector of naval matériel in Hartford, predicted that with an all-out effort on the part of American management and labor the enemy would be beaten—not when he cries "enough," but when he is thoroughly crushed by our might and power. Other speakers were Lieut. Col. Thomas L. Hapgood, U.S.A.; E. L. Milliken, manager of the Hartford District, W.P.B.; C. C. Stevens, conference co-ordinating committee chairman; and A. H. d'Arcambal, vice-president of the Pratt & Whitney Division of Niles-Bement-Pond, officiating as toastmaster.

The evening panel discussions were on the subjects, "Production Inspection," held under the leadership of F. O. Hoagland, Niles-Bement-Pond, and "Selection and Training of Personnel for Industry," conducted under the leadership of Joseph Barre, Pratt & Whitney Division.

Army Personnel at Afternoon Session

The day's program began in the afternoon when Mr. Smith welcomed the participants. Talks on conversion were delivered by Lieut. Col. J. H. Young, chief of the industrial division at the Springfield Armory, and Captain D. F. Linsley, chief of the conversion section at the Armory, who exhibited motion pictures on the proper use and conservation of strategic materials.

Atlanta Section Hears Science of Survival

THE Dec. 14 meeting of Atlanta Section featured Col. Joseph L. Walsh, U. S. Army Ordnance Department, as guest speaker. The topic chosen was "The Science of Survival," a challenging analysis of modern problems. An audience of 85 members and guests turned out to hear this most interesting talk. In addition to the noon meeting a night get-together was held in honor of Col. Walsh at the Atlanta Athletic Club.

The Victory Twins at Baltimore Section

More than 85 members and guests heard Henry E. Dralle, of Westinghouse Elec. and Mfg. Co., address Baltimore Section Feb. 1 on the topic, "The Victory Twins—Electricity and Oil." The meeting held jointly with A.I.E.E. proved most timely. The speaker dealt primarily with the use of electricity in the oil industry; in drilling wells, operating after drilling, and piping to the market. Of special interest was his discussion of well drilling all over the world and his description of the pipe lines under construction to relieve the east-coast shortage. Many interesting slides were shown.

Record Crowd at Bridgeport Greets Pioneer in Induction Heating

Over 300 members and guests were present at the Feb. 25 meeting of Bridgeport Section. The speaker of the evening, Dr. H. B. Osborn, of Tocco Co., is a recognized authority in the field of induction heating. He first discussed the elements of induction and conduction heating in relation to preparing metals, such as copper, brass, and steel for heat-treating and hardening. He then discussed induction heating in detail, covering the many methods employed to suit various demands and uses. Following this, the speaker displayed a set of slides with actual demonstrations of these methods and their installations. John Gross, a representative of the Manning-Maxwell and Moore Co., also presented some slides telling of his company's experience in induction heating, using the electric Bourdon tube. Following both speakers, a question period ensued bringing to light many challenging problems.

Chicago Holds Two February Meetings

The Feb. 8 meeting of Chicago Section had as guest speaker Dr. F. N. Alquist, who addressed the members on the subject, "The Chemical Cleaning of Power-Plant Equipment." An account of the selection of chemicals and methods used in cleaning various power-plant and process equipment was presented by Dr. Alquist. Scale samples, photographs, and comparative X-ray negatives were exhibited. Typical cases of removing scale were described which clearly illustrated the superiority of the method over other known methods from the standpoints of economy and results, in these cases.

The Feb. 16 meeting featured Nicholas A. Andree who spoke on "The Advantages and Scope of Magnetic Inspection in War Industries." He treated of the topic of "magnaflux," how it works and why it is used. As a nondestructive technique for locating surface flaws in steel, it has been widely adopted. The technique lends itself well to the examination of new and old parts, and is therefore a definite tool in preventive maintenance.

Cleveland's Part in Northern Ohio War Production Clinic in January

The Northern Ohio War Production Clinic held in Cleveland on Jan. 27 had a total attendance of 1000 drawn from cities as far away as Erie, Penn. Cleveland Section participated in the many stimulating activities which were under the guidance of the general chairman, A. T. Colwell. The purpose of the clinic, like so many now being held in various parts of the country, was to exchange, examine, and disseminate information and experience on the engineering and management aspects of war-production problems. The program began with registration at 11 o'clock followed by an afternoon assembly. Speakers at the afternoon assembly were Major George L. Becker, U. S. Army Air Forces, Central Procurement District, Cleveland Area, Lieut. Commander William Baker, office of inspection of naval material, and C. J. Reese, president, Continental Motors Corp.

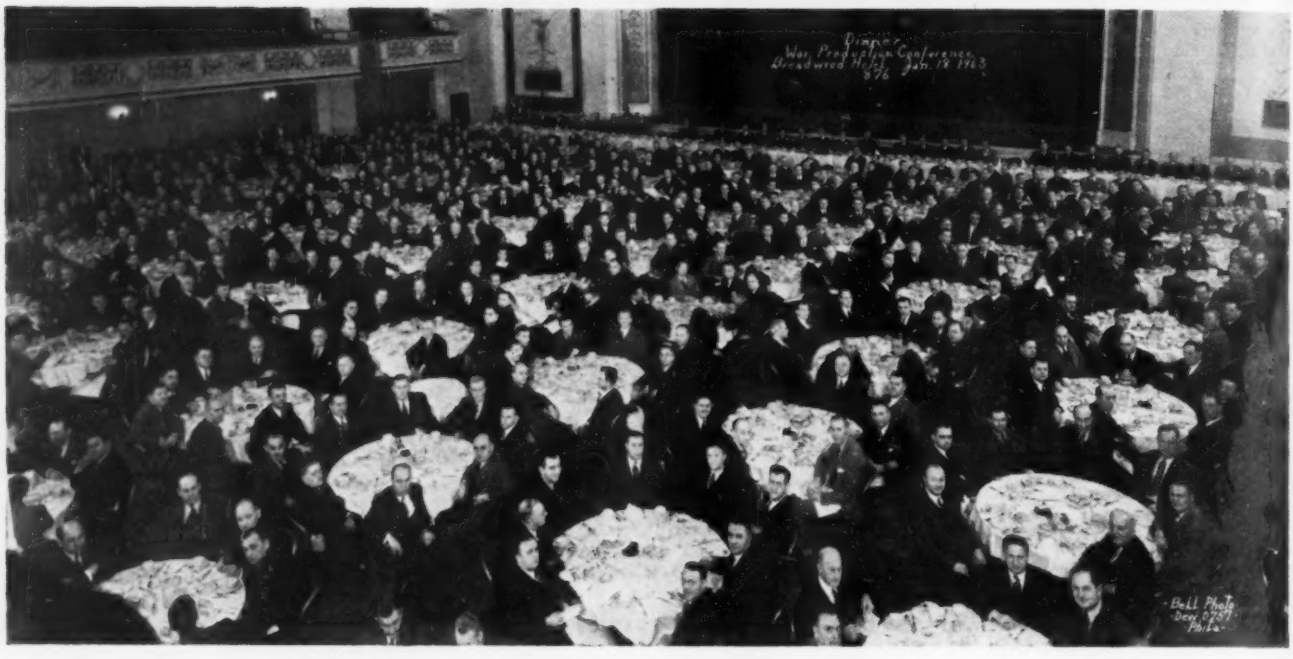
Panel meetings held in the afternoon covered a variety of subjects such as preventive maintenance; personnel and training; welding; utilization of idle plant; processing methods, tooling; inspection; planning and scheduling; material control; heat-treating methods, control and facilities; salvage of tools and material; controlled materials plan; and lighting, electrical problems, and motors.

Dinner and evening assembly wound up a busy day. Speakers at the dinner were Frank J. Lausche, Mayor of Cleveland, and William Loren Batt, vice-chairman of the War Production Board. The amount of provocative material presented plus the inspirational challenge of such a meeting cannot be overstated. Many more conventions of similar nature will do much for the establishment of rapport between people and government in an approach to the complexity of war-production problems.

The Feb. 11 meeting of Cleveland Section had as guest speaker Dr. Lillian M. Gilbreth, who spoke on "Women in Engineering." Her talk covered the history of women in the engineering profession, their present opportunities, and their future possibilities in engineering after the war.

At Columbus, Engineering and Human Motivation

Members and guests of Columbus Section heard C. A. Norman, professor of machine



RESULTS OF AMERICAN INGENUITY IN ENGINEERING AND PRODUCTION ARE REPORTED TO EXECUTIVES AND ENGINEERS OF PHILADELPHIA AT WAR PRODUCTION CONFERENCE

(Under the auspices of the Philadelphia Division of the War Production Board, Philadelphia Section of the A.S.M.E., and other engineering organizations, a War Production Conference was held in Philadelphia, Pa., on the afternoon and evening of Jan. 18. Subjects covered included production, salvage, women in industry, accident prevention, electrical problems, conservation of materials in welding, metallurgy, tools, dies, fixtures, plant heating and ventilating, castings, and machine cutting tools.)

design at Ohio State University, discuss "Engineering and Human Motivation" at the Jan. 29 meeting. His talk, illustrated with slides, showed the effect of technical organization and devices upon general human attitudes and problems. This proved to be a most unusual topic.

Dayton Section Draws 300

A record audience assembled on Jan. 12 to hear Prof. John F. Kahles of the University of Cincinnati, who discussed the topic, "Alloys From Powdered Metals," presenting an exhibit in connection with his talk. The evening proved most interesting and profitable to all Dayton Section members and guests.

Detroit Engineers Hear About Manpower and the Engineer

One of the best meetings so far this year was held by Detroit Section on Feb. 2 when it was addressed by Montague A. Clark, district director of the War Manpower Commission, on the subject of "War Manpower and the Mechanical Engineer." To an audience of 150 members and guests, the speaker pointed out that more men and women will be required to man the many war industries and also that sacrifices on the home front will increase in number and severity. He mentioned the number of men from Detroit expected to join the armed forces this year and said that the problem of replacing them as well as supplying more men, due to expanding industry, was a gigantic one. It is hoped that women and workers in nonessential industries will make up for the loss to the Army. Mr. Clark then discussed several of the current labor regulations in industry, after which a discussion and question period followed.

Detroit Juniors Absorb "Transport Vehicles"

Members and friends of the Detroit Junior Group met on Feb. 16 to hear a talk on the Holley carburetor, and Major E. N. Holtzkemper on "Transport Vehicles." The latter pointed out that modern vehicles were standardized to facilitate repair at the battle areas. He also stated that newer models were larger but with the same silhouette. The usefulness of the jeep came in for its share of discussion. The meeting proved most interesting to all.

Electronics, the Miracle Worker at Kansas

On Feb. 25 members and guests of the Kansas Section heard W. B. Frackelton, General Electric Co., speak about "Practical Industrial Electronic Control." In his talk, the speaker gave a brief history of the field of electronics, the science of the electron, dating from the time of the discovery of the Edison effect, the basis of modern electronics, to the present time. He described a number of the practical industrial applications of the system and talked, in passing, of the miracles to come from this relatively new science.

Milwaukee Section Has Huge Attendance

The Milwaukee Section met jointly with the Engineers' Society of Milwaukee and the A.S.M. on Feb. 17. A record audience of 400 turned out to hear Norbert K. Koebel talk on the subject "Modern Heat-Treating Methods and Equipment." The program began with the "world premier" of a colored talking film, "Heat-Treating Hints," showing many valuable points in the best modern heat-treating practice. Included were scenes of flame hardening, methods for providing protective covering for tungsten, a varied assortment of quenching tips, and other important ideas, especially on straightening and shrinking.

The second section of the program consisted of the talk by the speaker mentioned, Norbert K. Koebel, author of the book, "Industrial Controlled Atmospheres," and numerous articles on controlled-atmosphere heat-treating, who discussed this type of heat-treating most ably. Particular emphasis was placed on forced-convection furnaces and the components of the controlled atmosphere in the furnace. Special reference was made to the use of these heat-treatments in the manufacture of war goods. The speaker stated his belief that the demands of the war program had served to push heat-treating advances ten years beyond the point they would have reached in the normal course of events.

Working on the Railroad at New Haven

For their Feb. 16 meeting members and guests of New Haven Section chose as guest speaker Charles E. Williams, N.Y.N.H.R.R. A sound picture, portraying the passenger and freight handling and repair work of the railroad, opened the program. A short question and answer period followed. Then Sidney Withington displayed and commented on prints of English automobiles in use prior to 1840. The guest speaker then presented his account of "A Great Railroad at Work."

New Orleans Holds War Production Clinic

The War Production Clinic held in New Orleans on Jan. 14 proved a high light of the

year. Total attendance at the clinic numbered over 750. Panel discussions were along the following lines: welding and metal coating; industrial safety; women in industry; electrical problems. Clinics of such a nature do much in bringing to light possible solutions to many timely problems.

On February 8, members and guests of New Orleans Section heard J. W. Decvorse, assistant to the manager, new products department, U. S. Rubber Co., who talked on "Structural Rubber for Vibration and Impact." Fundamentals of design of rubber mountings for vibration absorption and characteristics of these mountings were presented to the audience of over 125, composed partly of the visiting Louisiana Engineering Society.

North Texas Meets Jointly With A.I.E.E.

An excellent program attracted a large audience of almost 200 at the Jan. 18 meeting of North Texas Section. A film, "Bouncing Ball," demonstrated the composition and process of making butadiene and finished rubber, by the use of models showing the molecular structures of and changes made in the hydrocarbons. Dr. C. S. Kuhn of Magnolia Petroleum Co. was speaker of the evening.

He elaborated upon the film and then proceeded to discuss the synthetic-rubber program of 1,100,000 tons and the enormous task that lies ahead. Dr. Kuhn also discussed the various types of synthetic rubber to be produced. It proved to be one of the most interesting meetings of the year.

Philadelphia Section Holds Clinic on War Production Problems

The War Production Conference held on Jan. 18 by Philadelphia Section and others proved most successful. At the afternoon meeting attendance was about 800 and at the dinner 850, but most gratifying of all was the 1500 rolled up for attendance at the panel discussions in the evening. Reason for the large attendance was the lively quality of the discussions themselves and plans are being made for more of the same in the future.

At their Feb. 23 meeting, members and guests heard Henry C. F. Meyer, of Gibbs and Cox, talk on the present and past long-range programs of the merchant marine ships. He stressed the importance of interchangeability of ship equipment, the making of models, the need of using proved designs. He called this most interesting talk "Learned From Liberty Ships."

Ship-Propulsion Gears at Providence

The Mar. 2 meeting of Providence Section featured R. L. Morey, engineer with General Electric Co., who discussed "Ship-Propulsion Gears." He told of various methods of design and manufacture of ship-propulsion gears and illustrated his points with lantern slides showing how such gears are used in modern cargo ships.

Rock River Valley Learns About Airplane's Part in Winning War

On Feb. 24, the Rock River Valley Section presented as guest speaker Colonel F. O. Dice, U. S. Army Air Corps, who gave a very interesting talk on the airplane's part in winning the war. Guest organizations at the meeting, which was held in Madison, Wisconsin, included the A.S.M.E. and S.A.E. Student Branches at the University of Wisconsin, the Madison Chapter of the A.I.E.E., and the Madison Technical Club. The attendance included 47 at the dinner and more than 400 at the meeting which followed.

Raleigh Section Holds Luncheon as Part of Annual Convention

The annual convention of North Carolina Society of Engineers held on Jan. 29 had as a special feature the Raleigh Section of A.S.M.E., sponsoring a luncheon for all of the A.S.M.E. members and guests. It was most successful.

National Emergency Steels The Topic at San Francisco

Members and guests of San Francisco Section at their Jan. 28 meeting had as guest speaker W. P. Wallace, metallurgist for Columbia Steel Co., who presented a paper on "National Emergency Steels." He presented reasons for conservation of such elements as nickel, chrome, vanadium, etc. Next he explored the hardening problems resulting from the use of various elements and then developed the method for hardness testing of samples.

An innovation at this meeting was the introduction of a series of discussions on Society organization. Five- or ten-minute talks will be delivered on this subject at meetings for the rest of the year.

Dual Bill at Southern California

The Feb. 11 meeting of Southern California Section was honored by the presence of Dr. Dexter S. Kimball, past-president, The American Society of Mechanical Engineers, in 1922, and now dean emeritus of the College of Engineering, Cornell University, who came to meet some of his old friends. Col. William H. Neblett delivered an address on "Training the United States Air Force for Combat Duty," while William T. Foran, geologist for Filtrol Corporation, spoke on "History of the Struggle for Oil."

War Production Conference Occupies Upper Tennessee

A very successful War Production Conference was held on Jan. 29 by members of Upper Tennessee Section. W. W. Mynatt, area manager of the War Production Board in Knoxville, was especially co-operative. Thanks for the success of the conference also goes to Tennessee Eastman Corporation, of which James C. White is general manager, which made it possible, at considerable expense to themselves, for guests to enjoy their cafeteria and auditorium.

Utah Hears About Tool Conservation

Feb. 15 was the date of the meeting of Utah Section. Speaker of the evening was LeRoy Davis, who after speaking presented a film on "Save Those Tools."

Air Conditioning Aired at West Virginia Section

"How Air Conditioning Has Advanced the Art of Refrigeration" gave members and guests of West Virginia Section a lot to think about at their Feb. 23 meeting. The speaker, Dr. Willis H. Carrier, chairman of the board of Carrier Corporation, presented a paper. The famed engineer stated that the need for power-driven pumps for coal mines brought forth the Newcomen engine, whereas the ready-made demand for a new source of power gave birth to Watt's steam engine. "That one industry should play an important part in the development of another industry is by no means a unique experience in the developments of the machine age. Air conditioning and refrigeration have been entirely dependent upon each other for the great advances that have been made in these arts during the past two decades." The speaker then reminded his audience that although air conditioning is usually associated with comfort, today, industries such as aircraft, munitions, and chemicals are using it to increase war production.

Plastics at Worcester

An excellent meeting was held on Feb. 9, at which members and guests of Worcester Section heard E. W. Vaill talk on "Plastics." The speaker mentioned the suitability of various types of plastics for different types of applications. He not only discussed the properties of each kind of plastic but outlined new uses, especially war uses and what may be expected in the way of future uses. He stressed the fact that plastics are not a substitute but an engineering material in their own right.

Economics of War Power Supply Before Western Massachusetts

The Western Massachusetts Section held its regular monthly dinner meeting in Springfield, Mass., on Feb. 16. R. R. Habberly introduced Dr. C. W. Kellogg, president of the Edison Electric Institute, whose topic was "Economics of War Power Supply." In his opening remarks, he pointed out that while many of our basic materials have been placed on the ration list, the electric-utility field still has a margin of about 10,000,000 kw before it will be necessary to apply rationing, and showed how electric-energy requirements follow very closely the volume of industrial production. In conclusion, the speaker stated that the electric power industry may be relied upon to deliver the power that will be required in the busy postwar era as it has in the present war period.

1942 A.S.M.E. Group Delegates Conference Endorses New Method for Handling Agenda Material

Revised Procedure Designed to Eliminate Unnecessary Items Requires Endorsement of Items by Several Sections

By F. L. Wilkinson, Jr.
Chairman, Committee on Local Sections

THE sixteen delegates from the eight groups of local sections of The American Society of Mechanical Engineers met in New York during the 1942 Annual Meeting and labored for three days over questions of Society policy and matters relating to the affairs of the seventy local sections.

Those members of the Society who have not had the privilege of attending an annual Group Delegates Conference can have little idea of the tremendous amount of work performed by this body of delegates who are representative of the membership of the local sections. They consider matters placed on the agenda and previously acted upon by delegates from each section, meeting in eight regional conferences prior to the Annual Meeting in December.

The delegates, therefore, have before them at the conference the opinions of the local sections on all matters included in the agenda. The conference takes definite action on each item presented and makes recommendations to the Council concerning each question brought to it from the eight regional conferences. The Council in turn considers the report of the delegates, refers certain items to the standing committees concerned, and usually takes definite action on these items at its meeting during the Semi-Annual Meeting of the Society.

The list of topics for consideration by the Group Delegates Conference has grown in length through the years and, therefore, unfortunately, has each year contained many items that are either of limited interest to the general membership or have already been considered or acted upon by conferences of other years and by the Council. This has tended to prolong the conference meetings and to limit the time available for delegates in their consideration of new items that are of major concern to the membership at large.

The 1942 group delegates were acutely aware of the time taken up by nonproductive items which covered almost fifty per cent of the agenda considered. They therefore recommended a procedure for the preparation of future agenda material and instructed the Committee on Local Sections to inform the membership of their action through the medium of MECHANICAL ENGINEERING.

Revised Procedure

The procedure for preparing agenda material for the eight sections delegates conferences in October and the Group Delegates Conference in December, as determined by the 1942 group delegates, is as follows:

1 The Council, professional divisions, standing committees, and all other groups within the Society are requested to contribute to the agenda, through the agenda chairman, subjects of a general and controversial nature on which an expression of opinion by the local sections delegates might prove valuable.

2 The agenda, prepared from suggestions of the above agencies is sent to each local section for consideration. After consideration by the local sections, each section will forward to the agenda chairman a list showing the items (by number designation) which they endorse for discussion at the sections delegates conferences and the Group Delegates Conference. The agenda chairman will then notify the chairmen of the sections delegates conferences in accordance with the following procedure established by the 1942 conference:

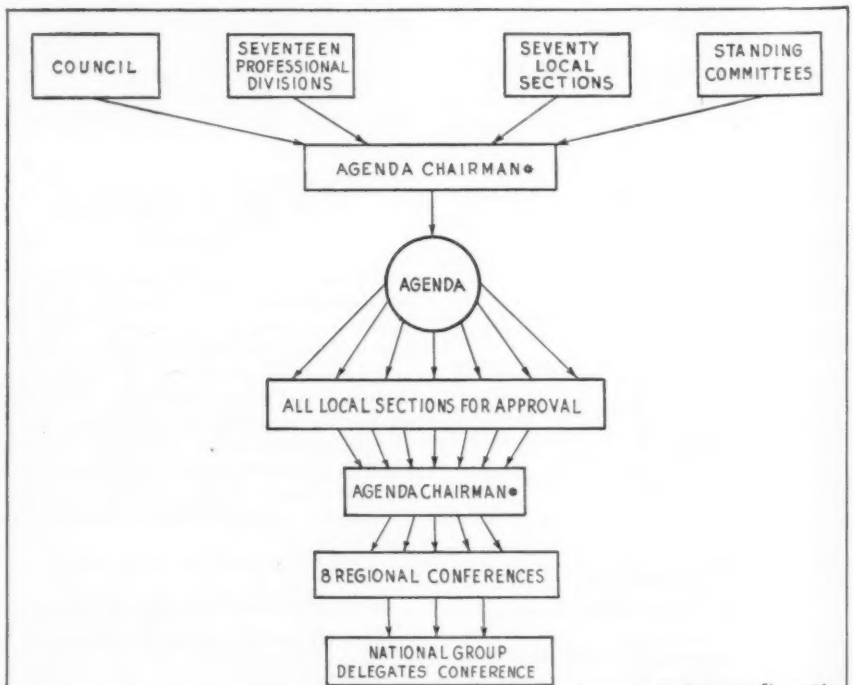
No items shall be considered by the sections delegates conferences unless approved by at least three local sections. It is suggested that, upon receipt of the agenda by the local sections, their executive committees shall consider each item and indicate in writing to the agenda chairman the items which they favor discussing. Items which do not receive such approval by three local sections shall be listed by the agenda chairman, a copy of the list shall be transmitted to the chairman of each sections delegates conference, and such items shall receive no consideration by the conferences and shall not be included in the agenda of the Group Delegates Conference except as hereinafter provided. It is suggested that such items be referred to the Local Sections Committee. However, items which have failed of approval by three local sections may be placed before a sections delegates conference by the delegate from the local section which submitted the item and, if approved by that conference, may be included in the agenda of the Group Delegates Conference; and further, none of the foregoing shall be construed as obviating the present practice of placing before sections delegates conferences items not on the agenda, or of including in the agenda of the Group Delegates Conference, provided they are approved by a sections delegates conference.

How Procedure Works

To illustrate the procedure for the preparation of the agenda, the 1942 Group Delegates Conference prepared a flow sheet illustrative of the procedure. This is reproduced here in order that the flow of material may be clearly understood.

The amount of work imposed on the chairman is evident from the description of procedure. The initiating agencies appearing at the top of the flow sheet are therefore urged to furnish their contributions to the agenda at the earliest possible date and in no event later than June 20, 1943, the dead line for agenda material.

The time is short, and the work of the chairman is voluminous. You are urged to act now.



FLOW DIAGRAM OF PROCEDURE OF GROUP DELEGATES CONFERENCE

AT MEETING OF A.S.M.E. STUDENT BRANCH AT CASE SCHOOL OF APPLIED SCIENCE PROF. AND MRS. R. V. BROWN EMERGING FROM TUNNEL EXIT OF "BOMB SHELTER"

With the Student Branches

Pictures of Case Branch's "Commando" Dance Appear in Country's Newspapers

Maneuvers Over and Through Obstacles on Gymnasium Floor for Members and Dates Main Feature of Affair

MEMBERS of the Case Branch of The American Society of Mechanical Engineers took time out from their wartime studies on the evening of Jan. 30 to hold a "Commando" dance at the Case Club in Cleveland. With their dates, the members were put through a series of tactics similar in some respects to those used in training "Commandos." Obstacles were placed around the balcony track of the club, which is used as the school's gymnasium, compelling the participants to crawl over and under them. After the maneuvers were completed the crowd enjoyed a pleasant evening of dancing.

The maneuvers of the "Commando" dancers started through a long dugout made of horizontal bars and wrestling pads; then onto a springboard, over a hurdle, through a maze of obstacles and a mess of simulated barbed-wire entanglements; then over a bridge consisting of a ladder suspended over space; and finally a slide down a pole from the balcony to the dance floor. Record time for the course was one minute flat.

Student Papers at Arkansas

Speakers at the Feb. 22 meeting of Arkansas Branch were student members Fred Sims, Robert Duncan, and Boyd Purifoy. They gave talks on the following subjects: "Piston Rings and High-Speed Engines," "Welding," and "Problems, Characteristics, and Uses of Wood in the Aircraft Industry," respectively.

Arizona Branch members met on Feb. 3 and discussed plans for possible variations in the meetings for the coming semester. Following the business discussion, a technicolor motion picture on arc welding was shown through the courtesy of the General Electric Co.

British Columbia Branch changed its meeting day from Wednesday to Monday in order to avoid conflicts with other university activities. Consequently, the meeting of Jan. 18 was held on Monday. Two members, J. Porter and J. Wighton, talked on "Maintenance of Locomotives at the Local Canadian National Railroad Repair Shops," and "Die Making," respectively. The Vancouver Engineering Works was the scene of a field trip conducted by the Branch on Jan. 23. Members saw the manufacture of many vital parts, such as castings and forgings, for locally built 10,000-ton freighters. A proposed banquet had to be indefinitely postponed because of local weather conditions which resulted in the closing of the University.

Brooklyn Poly Branch has decided to feature papers by student members at its meetings. On Jan. 14, H. Waller and R. Jackson spoke on their experiences during the last summer at the Pratt & Whitney Co. plant in Hartford, Conn. Both men worked as assistants to test engineers in the engine testing "cells" and each had some interesting experiences to recount. They covered, between them, the test procedure, routing of the work, and the test-department organization. To make it more interesting, Mr. Waller brought with him some broken-down parts of the large 2000-hp engine and passed them around.

Meeting Follows Cincinnati Luncheon

After a luncheon had been stowed away, members of the Cincinnati Branch on Feb. 9 heard the rendition of several songs by the "Dynamometer Five." The program part of the meeting consisted of motion pictures on "Saving Scrap for Victory," "The Coaxial Cable," and "Boulder Dam."

Colorado State College Branch met on Jan. 18 and heard Everett Selleck give a paper relating his experiences at the Pratt & Whitney Co. plant where he was employed during the past summer. On Feb. 1, Richard Grabowsky, who worked for the Ryan Aeronautical Company, told of his summer work at that plant. A motion picture on the manufacture of a V-type engine was shown on Feb. 15.

Cornell Branch held a meeting on Jan. 19 in conjunction with the Ithaca Section of the A.S.M.E. The speaker for the evening was L. M. Currie, assistant director of research for the National Carbon Company, who gave a very interesting talk on plastics. Mr. Currie brought along a number of charts showing the properties of various plastics and the uses to which each is put.

Drexel Branch met at the Institute on Feb. 10 and discussed various items of business. The session was then adjourned and the group proceeded to the Philadelphia Engineers Club to hear a presentation of a paper on "Water Treatment" delivered by Forest W. Brainerd, Scott Paper Co., at the monthly meeting of the Philadelphia Junior Group.

Florida Branch featured five papers at the Jan. 21 meeting. One of the papers described some of the latest instruments developed for the safety of the airplane pilot. Another paper discussed the ability of the Stromberg carburetor to supply an aviation engine with better than 200 gph in an erect or inverted position.

Idaho Branch elected officers for the new semester on Jan. 27. Arthur Lewis is the new chairman.

Good Attendance at Iowa Sessions

At meetings held by Iowa Branch in January and February, the student speakers included Mueller, discussing "Tank Construction and Armament;" Multhaup, talking on the subject of copper in defense work; Sturdevant, describing the processing of clay products; Mahan, outlining the qualifications for law college; Ralston, talking about meteorology; Lamb, featuring the subject of bomber construction; Hogle, talking on the U. S. Army Ordnance Department; and Stein, listing the qualifications needed in order to pass the professional engineering license examination. Attendance at these meetings range from 39 to 49 per meeting.

Iowa State College Branch held a meeting on Feb. 3 at which Professor Grace spoke and showed slides on "Mining Districts in Colorado."

War Subjects Feature Kentucky Sessions

A motion picture, entitled "Target for Tonight," which gave an account of a successful British bombing raid on Germany, was shown at the Jan. 22 meeting of Kentucky Branch. This picture presented all the thrills and suspense of modern aerial warfare—plans for

MEMBERS OF THE A.S.M.E. UNIVERSITY OF KENTUCKY STUDENT BRANCH

the attack, bombing scenes, antiaircraft fire, dangers encountered by the fliers, and the anxiety of those awaiting their return. On Feb. 5, Dr. E. F. Farquhar, professor of English, stated in his talk that democracy cannot be maintained by means of pacifism. His explanation of how so many engineering terms got into politics was very amusing. Among the examples cited were "pump priming," "steam roller," "pull," and "drag."

LOUISIANA STATE BRANCH held its first meeting of the new semester on Feb. 11 for the purpose of electing new members. After a discussion of each prospective's character and ability, votes were taken. In all, 34 were admitted to membership.

LOUISVILLE BRANCH held nine meetings during the first semester. Programs consisted of motion pictures, presentation of technical papers by student members, and business sessions.

Michigan Mines Wins Scrap Drive Prize

At the beginning of the second semester, MICHIGAN MINES BRANCH participated in a scrap drive and won second prize among campus organizations by collecting more than 2800 lb of scrap material in two weeks.

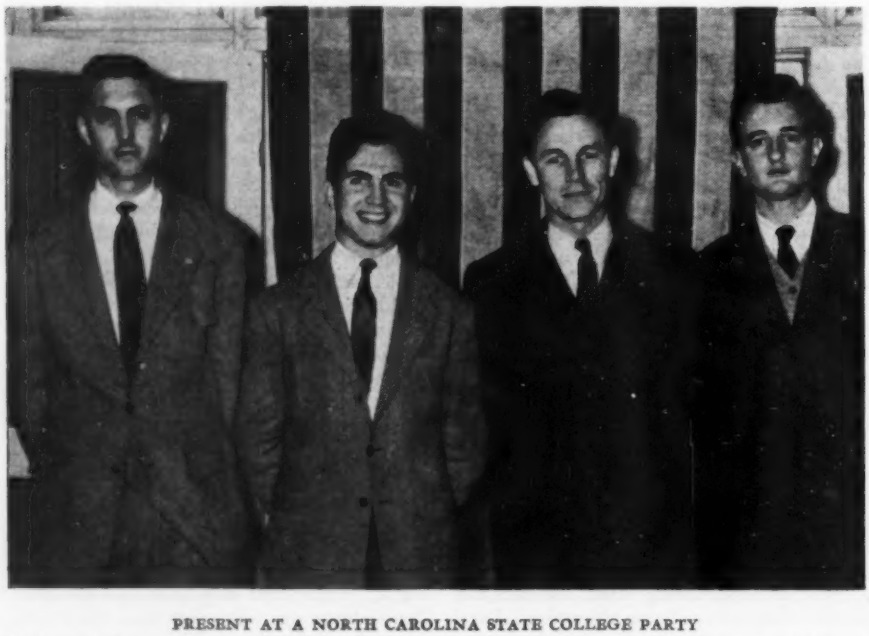
MISSOURI BRANCH discussed plans on Feb. 18 for the Branch's participation in the annual St. Pat's week celebration to be held in March. John Wills reviewed a paper, "The Second Mile," which was presented originally by Dr. W. E. Wickenden at Ontario, Canada. A technical paper on "Fuel-Injection Systems" was given by Harold Bragg.

NEBRASKA BRANCH devoted its meetings of Feb. 10 and 24 to the showing of motion pictures. Those exhibited included "Divide and Die," "Building a Tank," and "Target for Tonight."

NEW MEXICO BRANCH featured a motion picture on wrought-iron pipe at the Jan. 12 session. On Jan. 26, the members appropriated $10 as prizes for the best papers to be presented during the semester by student speakers.

North Carolina State Dances

On Jan. 30, NORTH CAROLINA STATE BRANCH held a joint dance with the aeronautical-engineering students. Jack Singer, secretary of the Branch, in reporting the dance says, "There was good music on records and some delicious refreshments. . . . Yours truly had the cutest date at the party Saturday night."



PRESENT AT A NORTH CAROLINA STATE COLLEGE PARTY

(Left to right: George Langley, vice-president of the Aero Society; Nick Geluso, president of Aero Society; I. J. Hetherington, president of A.S.M.E. Student Branch; Paul Ausman, vice-president A.S.M.E. Student Branch

NORTHWESTERN BRANCH held the first meeting of the quarter on Jan. 27. The program consisted of an exceedingly interesting lecture and demonstration by George Rose, Ethyl Gasoline Corporation, on "Gasoline of Today and Tomorrow." A test engine was run on various fuels, data were taken, and performance compared for the different fuels.

OHIO STATE BRANCH under the chairmanship of Miss Elizabeth Izant and the secretaryship of Edward Sing is having some very interesting meetings. On Jan. 22, Miss Viva Booth, director of the University's bureau of business research, spoke upon the effect of war upon prices and the correction of the bad conditions that result. She explained the results of inflation during the last war and reviewed the steps that have been taken during the present war to forestall the occurrence of similar conditions. At the Feb. 5 session, Dr. Paul N. Lehoczky, of the department of industrial engineering, gave a talk on "Industrial Safety and Its Relation to Mechanical Engineering." He emphasized that, in the past, engineers had neglected the human factor in the design of machinery, citing a number of typical cases to illustrate his point.

OKLAHOMA BRANCH had W. H. Stueve, as guest speaker at the Feb. 5 meeting. His subject consisted of a technical description of the construction of the new 24-in. oil pipe line from Texas to Illinois. After the talk, motion pictures on the project were shown.

OKLAHOMA A.&M. BRANCH members spent part of Washington's Birthday, Feb. 22, attending a meeting of the Branch. A short film on the instruction of arc welding prepared by Dr. Clark Dunn and Prof. William Rice of the faculty was presented.

OREGON STATE BRANCH met on Feb. 10 to transact some business and to view motion pictures on "Fluid Drive" and "Nickel Mining." Chairman Ed. Fearey reminded the students of the many benefits derived from the presentation of technical papers.

PENN STATE BRANCH members gathered on Feb. 9 to hear talks by Dean Hammond and Professor Everett. An interesting film on the applications of sand in the glass-making industry was shown.

R.P.I. BRANCH met on Feb. 2 to hear John Seaman and J. G. Flagler of the Behr Manning Corp. give a talk on "Manufacture of Sandpaper." The talk was supplemented with color movies.

Guest Speakers at Rice

During the weekly meetings in January, RICE BRANCH heard R. M. Garrison, chief engineer of the Mission Mfg. Co., talk on the subject, "The Young Engineer Seeks a Job," and Louis Lingler, The Sheffield Gage Corp., present an interesting and instructive lecture and demonstration on precision gages. On Feb. 16 an inspection trip was made to the Lone Star Cement Company's plant.

SANTA CLARA BRANCH presented at the Feb. 10 session a motion picture entitled "The Study of Motion." This picture demonstrated the fact that muscular fatigue could be greatly reduced by the use of simple assembly jigs. Howard Turner then presented a short

SOME MEMBERS OF THE A.S.M.E. UNIVERSITY OF WASHINGTON STUDENT BRANCH

(Left to right, *First row:* Dave McCurdy, Walter Carlson, chairman, Walter Novak, Richard Lottes, Charles Howe, Jack Wyard, Harvey Christiensen, John Bartley, John Engman; *Second row:* Henry Clausen, Garth Dickens, John Williams, Harry Wackter, George Tilbury, Dean Duffy, Oliver Laster, Secretary-Treasurer, Gene Bennett; *Third row:* Leonard Bonifaci, Harold Broomell, John Dolloff, Donald Dean, Charles Pohl, Paul O'Reilly, Lloyd Hull, vice-chairman, Charles McOmber, Wayne Van Winkle, Robert Humphrey.)

talk on "The Modern Development of Air-Cooled Aircraft Engines." The Feb. 17 meeting featured a paper on "The Liberty Aircraft Engine," by Walter Morris.

University of Southern California Branch adopted a resolution at the Feb. 8 meeting to reduce absenteeism at the meetings. It was also decided to have student members present more technical papers at the meetings.

South Dakota State Branch opened the meeting of Feb. 17 with singing led by Chairman William Campbell. A short film on steel production was then shown, followed by the serving of coffee and doughnuts.

Stanford Branch initiated 18 new members at the Feb. 3 dinner meeting held in Palo Alto. After the initiation, John Lenzen, Standard Oil Co., gave an interesting talk on the present supply and demand of petroleum, and of the possibilities of discovering new oil reserves. He brought out the point that present known reserves are very large and that there is very little danger of exhausting them if careful supervision is maintained.

Swarthmore Branch met on Feb. 17 to elect new officers and discuss plans for future meetings. It was decided to present several motion pictures at the next meeting.

Tennessee Branch at the evening meeting of Feb. 17 saw two motion pictures on "Shell Forging," presented by Tom Wright and Charles Cowan.

Tulane Branch devoted its session of Feb. 4 to the discussion of various items of business, such as the program for the next meeting, the membership drive, and the annual St. Pat's celebration on Mar. 20.

Vanderbilt Members Speak

William Gardner read a paper on "Aircraft Diesel Engines," and John P. Miser presented a talk on his development of a new cycle for an air engine at the Jan. 18 session of Vanderbilt Branch. Prior to the talks a general discussion took place as to the time and place for future meetings in order that all the members might attend, but no definite conclusion was reached.

Villanova Branch presented Otto de Lorenzi, Combustion Engineering Corp., as the speaker at the Jan. 12 session. He pointed out several economical improvements in the design of boilers and then showed three reels of colored motion pictures on different types of coal beds in furnaces at different times or stages of stoking.

Virginia Branch held an informal meeting on Feb. 9 for the purpose of exhibiting the N.A.C.A. technical film on spinning tests of model airplanes. A brief introduction to the film was given by the secretary, W. W. Willoughby.

Virginia Poly Branch had two motion pictures shown at the Feb. 15 session. They were entitled "Frequency Modulation" and "Excursion in Science." At the Feb. 22 meeting, Prof. John Richardson, of the physics department, lectured on X rays and crystal analysis. With the aid of several diagrams, he showed how Rankine discovered the X rays and explained the three methods of crystal analysis, namely, the Lane method, the Proden method, and rotating-crystal method.

George Washington Honors Members

As part of the program of the Feb. 3 meeting of George Washington Branch, Eugene Dedick was selected by vote of the members to receive the award of a Junior membership in the A.S.M.E. Dirk Brady was elected to represent the Branch in the University's Engineering Council. Finally, funds were appropriated to purchase an A.S.M.E. banner to be placed in the newly opened engineer's lounge located in the mechanical-engineering building.

Washington University Branch held its annual banquet on Jan. 30 in order to honor 16 senior students who were leaving the next week for the armed forces. Prof. R. R. Tucker, head of the mechanical-engineering department, opened the speaking part of the program with remarks to the departing members. He was followed by Harry Coopland, manager of the Hotel Roosevelt, who spoke on the subject, "Selling St. Louis." The main event of the evening was the presentation of an award to Robert C. Bown for his outstanding work on behalf of the A.S.M.E. Following the presentation ceremonies, the juniors presented a dramatic skit, entitled, "We Produce 'Em, Who Gets 'Em?" or "This Isn't the Army—Yet!"

Washington State Branch has inaugurated a project which might be of interest to other Student Branches. It is the erection of a world-wide map on which pins bearing the names of mechanical-engineering graduates and indicating their whereabouts have been placed.

Hydraulic Turbine Handbook Available

A 64-PAGE "Hydraulic Turbine Handbook," combining theory and practice for ready application to problems in everyday operation has recently been made available to hydraulic engineers by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Prepared by Arnold Pfau, consulting engineer for the company's hydraulic-turbine department, the publication covers the field of hydraulic prime movers in general, yet in concentrated form. It discusses principles of design and practical problems of speed and pressure regulation.

The comprehensive paper, R 6257, is divided into five parts, dealing with: general characteristics and types, theoretical characteristics, reliability of service and speed and pressure control, specific examples of pressure regulation, and hydraulic accessories.

Automatic Stations

THE fourth bibliography of technical literature entitled "Bibliography on Automatic Stations, 1930–1941" is soon to be issued by the American Institute of Electrical Engineers. This publication sponsored by the A.I.E.E. committee on automatic stations supplements earlier bibliographies on the subject published previously in A.I.E.E. Transactions. The material is divided into the following sections: General; supervisory and remote control; telemeter and telemetry; automatic and remote-controlled switches and switchgear; automatic features of generating stations using fuels; automatic boiler and combustion control; automatic hydroelectric plants; automatic substations.

The Bibliography will be obtainable from the A.I.E.E. headquarters, at 25 cents per copy for A.I.E.E. members, 50 cents to nonmembers.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MECHANICAL ENGINEER, 47, three dependents. Advanced degrees. Twenty-six years' marine and stationary Diesel engine design, marine and municipal power-plant design, construction, operation, and maintenance experience. Present engagement, consulting engineer. Me-794.

FACTORY EXECUTIVE, ASSISTANT TO PRESIDENT, 18 years' broad industry experience. Graduate mechanical engineer with year's advanced training M.I.T. and four-year machinist apprenticeship; American, 41; knows what to do and how to get it done. Me-795.

MECHANICAL ENGINEER, Stevens graduate; 35 years' experience on design and construction of medium-heavy machinery. Has worked closely with various departments of a large machine shop. Plant maintenance and estimating. Now employed but not in defense work. Desires to locate nearer New York City. Me-796.

MECHANICAL-ELECTRICAL ENGINEER with 16 years' experience in cable manufacturing, power-plant design and testing, and public-utility consulting, desires opportunity to obtain executive training in industry. Me-797-Detroit.

EXECUTIVE ENGINEER OR PLANT MANAGER, citizen, 34, married, A.B., M.A., New York license. Knows men, methods, materials, costing, accounting. Seeks responsible managerial position, handle organization in Pacific Coast aircraft firm making precision mechanical or electrical product. Me-798.

POSITIONS AVAILABLE

MECHANICAL ENGINEER with machinery-drafting experience for research department. Must be able to aid in drafting of successful commercial machine from present pilot equipment. Experience in fiber or paper helpful. Work interesting. Position permanent with successful company now engaged in war work. New York State. W-1381.

MECHANICAL ENGINEERS, not necessarily graduates, with good groundwork in fundamentals of mechanics. Should have experience in one or more of following: heat transfer, armaments, gun or torpedo installation equipment, hydraulics, aeronautical wing or fuselage, sheet-metal layout, knowledge of mechanisms, strength of materials or stress analysis. Prefer men who have had 3 to 5 years' experience on the board. Will be in aeronautical industry. Permanent. Write Personnel Service for application blanks. East. W-1690.

ASSISTANT WORKS MANAGER, with technical education, preferably in mechanical engineering, with background in either machine or tool-design fields, or as shop foreman or shop superintendent in industry where medium-heavy parts are machined in semiproduction quantities. Most of work done on turret lathes, but also have semiautomatic chucking machines and automatic screw machines. Permanent. Good opportunity for advancement in postwar period. $10,000 a year. Massachusetts. W-1766-B238.

MECHANICAL ENGINEERS experienced in woodworking. Must be seasoned executives, with balanced perspective of plant operation. Woodworking experience absolutely essential. Tennessee. W-1845.

DESIGNERS with optical-design experience. Should be qualified in designing optical elements in relationship to cameras, projectors, and other optical devices. New York State. W-1849.

MECHANICAL SUPERINTENDENT for ship-construction work. Prefer man with some experience on marine installation, such as main and deck machinery, although engineer who has been erecting power-plant equipment or heavy machinery may qualify. $4200–$5200 year. Permanent. Pennsylvania. W-1852.

MECHANICAL ENGINEER experienced in production and control for medium-heavy machine plant manufacturing cold-forging machinery, headers, thread rollers, etc. Some design experience desirable. $7500–$10,000 year. Connecticut. W-1861.

PRODUCTION MANAGER for small company manufacturing and machining ships' propellers and other marine accessories. About $6000 year. Machine-shop background necessary. New York metropolitan area. W-1866.

CHIEF INSPECTOR, not necessarily graduate engineer, to inspect quality machine-shop work, especially in regard to marine equipment. Knowledge of navy inspection requirements desirable. About $4000 a year. New York metropolitan area. W-1867.

ENGINEERS, graduates, 30–42, with at least 5 years' manufacturing experience. Previous industrial engineering experience desirable but not essential. Permanent. $6000–$9000 a year. New York, N. Y. W-1875.

ENGINEERS. (*a*) Production engineer, mechanical graduate preferred, for company manufacturing small semiprecision miscellaneous equipment. Salary, $3000–$5000 year. (*b*) Development engineer, mechanical or electrical, with some mechanical background and some previous development experience in products as described above. $3000–$5000 a year. Northern New Jersey. W-1878.

CHIEF TOOL DESIGNER AND PRODUCTION ENGINEER for large electrical-mechanical manufacturer. Must be able to determine materials and equipment necessary; must know operations of equipment, tool, and sequence; must be able to design and make tools; and must know plant layout. $6500–$7500 year. New England. W-1883.

PRODUCTION CONTROL AND PLANNING SUPERVISOR to convert sales schedules and requirements into factory schedules, material orders, and control machine loading, inventory control, factory disbursements and expenditures. $5500–$6000 year. New England. W-1885.

EDITORIAL WRITER experienced in writing either for technical trade paper or for technical publicity or advertising organization. Some background in steel, machine tools, or aviation desirable. Salary, $4500–$6000 year. Ohio. W-1892.

MECHANICAL OR PROJECT ENGINEER experienced in design and manufacture of lawn mowers, either hand- or power-operated, or both. Desire experienced man who could develop improvement in prewar lawn mowers for postwar marketing. New York State. W-1893.

METHODS ENGINEER AND SHOP SUPERINTENDENT. (*a*) Methods engineer experienced in machine shop, layout, motion study, tools from efficiency of operation for light semiprecision operations such as instruments, etc. $5000–$6000 year. (*b*) Shop superintendent or supervisor for machine shop, i.e., screw machine, milling, turret lathes, etc., for light medium precision work. Must be practical man as job is out in shop. $5000–$7500 year. New York State. W-1944.

MECHANICAL ENGINEER wanted to supervise the design and erection of piping aboard ship. It is desired that the applicant have had considerable marine experience although a good industrial background may qualify. War plant. $5000–$6000 a year. East. W-1947.

DESIGNER on tools and gages with enough practical experience to warrant his being placed in complete charge of all gage design and manufacture. Upward of $5000 year. Should be draft-exempt. New York State. W-1966.

ENGINEER who has had thorough and successful machine-shop and toolroom background who would be capable of taking over position of chief inspector. Upward of $5000 year. Should be draft-exempt. New York State. W-1967.

MECHANICAL ENGINEER OR PHYSICIST for assignment to study of vibrating mechanisms related to ore-dressing equipment. Mechanical engineer who has liking for theoretical aspects of vibrating problems desired. $3600–$4800 year. Ohio. W-1972.

(*A.S.M.E. News continued on page 306*)

[1]All men listed hold some form of A.S.M.E. membership.

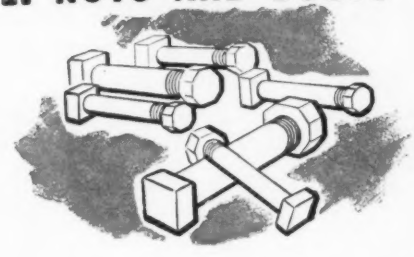
Welding piping with Tube-Turn fittings conserves 4 vital materials . . . checks war-time pipe failures, stops leaks!

NO. 4 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

The ★ FIRST WELDING FITTINGS 1st AND STILL THE BEST

1. NUTS AND BOLTS

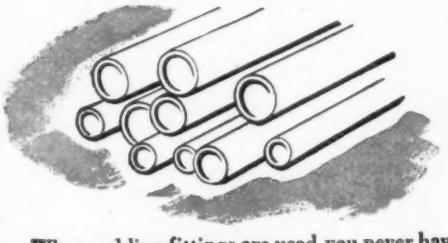


Joints welded with Tube-Turn fittings require no nuts or bolts. Maintenance time and trouble spent in tightening bolts is eliminated.

2. FLANGES

Welding fittings supplant the need for many of the flanged joints necessary in screwed piping—save both weight and critical metal.

3. PIPE REPLACEMENT



When welding fittings are used, you never have to replace any pipe because of worn threads or damage due to replacing flanged fittings.

4. GASKET MATERIAL

Fewer flanged joints mean fewer gaskets to replace. No materials or time wasted when connections are welded with Tube-Turn fittings.

When you multiply these savings over an entire piping system, the amount of critical materials conserved is tremendous. Tube-Turn welding fittings aid the war effort in *other* ways, too—less danger of plant shut-downs due to piping failures; maintenance is virtually eliminated; less installation time is needed because alignment is easier, only simple butt welds are required, and complete sections may be pre-assembled then welded into position. For *stronger, lighter, permanently leakproof* piping systems—weld with Tube-Turn fittings!

TUBE-TURNS (INC.) LOUISVILLE, KY. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Tulsa, Houston, Los Angeles. *Distributors in principal cities.*

TUBE-TURN

TRADE MARK

Welding Fittings and Flanges

1942 Book of A.S.T.M. Standards Available

THE recently completed 1942 Book of A.S.T.M. Standards, contains in their latest approved form all of that Society's widely used specifications and tests for materials, definitions, and recommended practices.

It is issued in three parts, the divisions being as follows:

Part I. Metals. Ferrous and nonferrous metals (all A and B and some E serial designations) except methods of chemical analysis. General testing methods (E serial designations).

Part II. Nonmetallic Materials—Constructional. Cementitious materials, concrete and aggregates, masonry building units, ceramics, pipe and tile, thermal insulating materials (all C serial designations). Timber and timber preservatives, paints, varnishes, and lacquers, road materials, waterproofing and roofing materials, soils (certain D serial designations). General testing methods, thermometers (E serial designations).

Part III. Nonmetallic Materials—General. Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water (remainder of D serial designations). General testing methods, thermometers (E serial designations).

(The Society is also issuing a new edition of its volume of chemical analysis of metals, including 21 widely used standards for both ferrous and nonferrous metals. This book will be issued later in 1943. These methods are not included in the Book of Standards.)

Each part of the 1942 Book has a complete subject index.

1943–1944 Supplements, Detailed Index

To keep the books up to date in 1943 and 1944, a supplement will be issued to *each* part in *each* of these years. As a service with the 1942 Book of Standards there is a complete 200-page Index to Standards, which is furnished without additional charge and a copy accompanies the purchase of each part or complete set.

The cost of each Part of the 1942 Book of A.S.T.M. Standards is $9; the charge for Supplements is $3 for *each* part, *each* year. For half-leather binding add $1 extra for *each* part and *each* Supplement part. Copies may be obtained from the American Society for Testing Materials, 260 South Broad St., Philadelphia, Pa.

Coal Bureau Moves to New York

BECAUSE it is now concentrating largely on war and postwar activities and its program has to do with markets, consulting engineers, and equipment manufacturers located principally in the East, offices of the Coal Bureau of the Upper Monongahela Valley Association will be moved to New York City, March 15.

Certain Coal Bureau activities will continue to be conducted from the offices of the Upper Monongahela Valley Association in the Peoples Building, Fairmont, W. Va. Julian E. Tobey, managing director, will be located in the Chanin Building, 122 East 42 St., New York, N. Y.

Recently the Bureau has been working with government agencies and plants engaged in war production, which are facing fuel shortages and oil-conversion problems. This is in addition to a consultation service maintained for members and sales agents and many investigations conducted of industrial-plant requirements.

While in the future it is planned to continue a modest advertising program along educational lines, major emphasis from the New York office will be placed on postwar markets and the important part coal costs will play in the future industrial picture, Mr. Tobey stated.

Lamme Medal Awarded to Joseph Slepian

THE 1942 Lamme Medal of the American Institute of Electrical Engineers has been awarded to Dr. Joseph Slepian, associate director of research, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., "for his contributions to the development of circuit-interrupting and current-rectifying apparatus." The medal and certificate will be presented to him at the National Technical Meeting of the Institute, which is to be held in Cleveland, Ohio, June 21–25, 1943.

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Company, who died on July 8, 1924, to provide for the award by the Institute of a gold medal (together with a bronze replica thereof) annually to a member of the American Institute of Electrical Engineers, "who has shown meritorious achievement in the development of electrical apparatus or machinery" and for the award of two such medals in some years if the accumulation from the funds warrants. A committee composed of nine members of the Institute awards the medal.

Appointed A.S.H.V.E. Technical Secretary

THE appointment of Carl H. Flink as technical secretary of the American Society of Heating and Ventilating Engineers has been announced by President M. F. Blankin. In this position Mr. Flink will be responsible for the co-ordination of technical committee work and assist in the compilation of codes and standards and work closely with the Guide Publication Committee in the preparation of this annual reference book of the Society. He will be at the headquarters office of the Society, 51 Madison Ave., New York, N. Y.

A.S.M.E. Woman's Auxiliary Honors Mrs. F. M. Gibson

MRS. FREDERICK M. Gibson, past-president of the Woman's Auxiliary to the A.S.M.E., was honored at a luncheon on Wednesday, February 24, at the Engineering Woman's Club, 2 Fifth Avenue, New York, N. Y. Twenty-four members of the Auxiliary who had served with Mrs. Gibson attended the luncheon; three of them, Mrs. J. P. Harbeson, Mrs. J. McCarthy, and Mrs. E. F. Zeiner, came from Philadelphia.

As a token of the esteem and affection held for Mrs. Gibson by her associates she was given a sterling-silver sandwich plate. The presentation was made by Mrs. E. C. M. Stahl, the newly elected president of the Auxiliary.

Mrs. Crosby Field and Mrs. Clifford B. Le Page were in charge of the luncheon.

MRS. A. R. CULLIMORE
Publicity Chairman

Mineral-Wool Cold-Storage Insulation Standard

THE National Bureau of Standards, U. S. Department of Commerce, in co-operation with the Industrial Mineral Wool Institute, has announced the successful establishment of Commercial Standard CS 105-43, Mineral Wool; Loose, Granulated, or Felted Form, in Low-Temperature Installations.

The Standard covers both cold-storage area and pipe-line mineral-wool insulation. Until the printed standard is available, mimeographed copies of Commercial Standards CS 105–43 may be obtained free of charge from the Trade Standards Division, National Bureau of Standards, Washington, D. C. Single copies may be secured without charge from the Industrial Mineral Wool Institute, 441 Lexington Avenue, New York, N. Y.

Fellowships at 11 Schools Sponsored by Gulf Oil

THE Gulf Oil Corporation has announced the inauguration of fellowships in the fields of physics, chemistry, geology, engineering, and business administration at 11 of the country's foremost colleges and universities.

Applications Must Be Made to Colleges

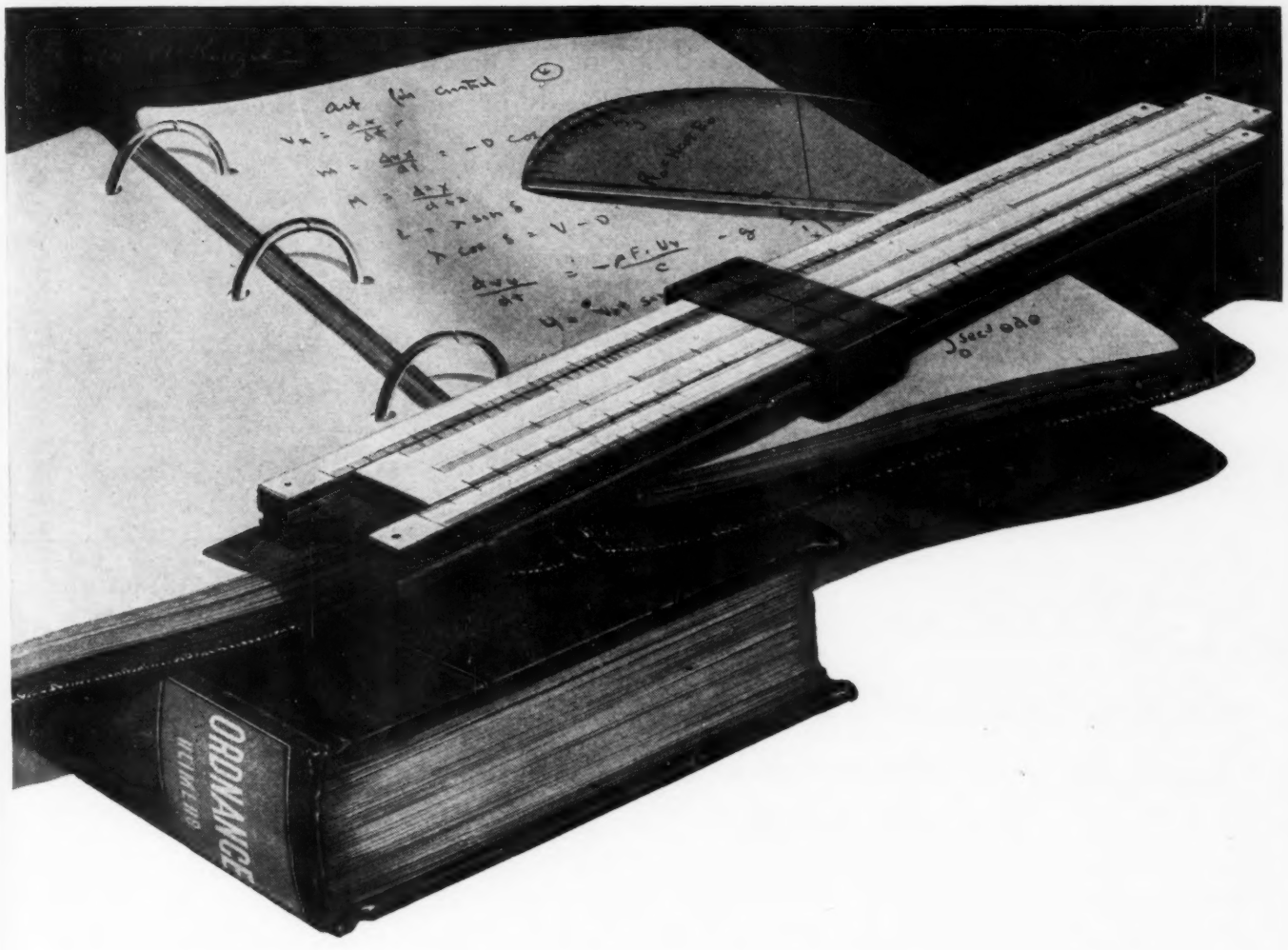
Application for the fellowships is open to graduates of recognized colleges and universities and to men or women who, through established training and achievement, are able to demonstrate their preparedness for advanced training. Those interested in qualifying must make application directly to the participating institutions. Complete details of the plan, together with the proper procedure for making application, will be made through college publications and scientific journals.

In announcing the creation of the fellowships, the Gulf management openly recognized that America and the world is dependent upon science for its industrial progress, and that science can be made available and can be applied only by trained men.

Problems of New Industries Must Be Solved

As each year passes, the problems of industry become more complex. In just the last few years, such increasingly important industries as synthetic rubber, higher-octane aviation gasoline, plastics, and others have had their beginnings. Relatively little is known about many of the new industries and only through the utilization of science can their products be made of greatest use to the public.

(*A.S.M.E. News continued on page 308*)



What's a cotangent got to do with ack-ack?

PLENTY. So have sines, cosines, squares and square roots, differential equations, and integral calculus.

For the accurate firing of anti-aircraft batteries depends wholly upon the science of mathematical calculations that must be made fast—faster than a score of the most brilliant mathematicians could do it!

To solve these problems—to make the ack-ack of the United Nations deadlier—Westinghouse engineers are assisting in the development of an improved "electric brain" that makes the necessary lightning-like calculations.

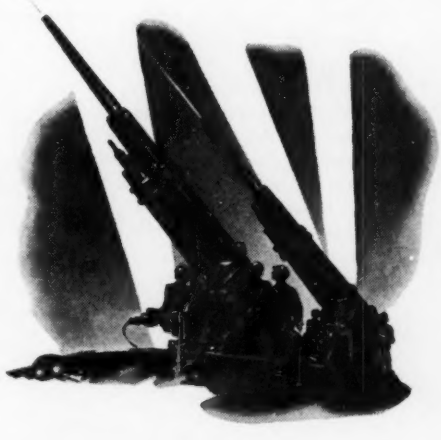
The firing control—known as the "computing director"—not only *locates* the exact position of the target as it twists and dodges through the sky. It also *calculates* where the enemy plane will be by the time the shell has traveled 10,000 or more feet into the air—all in a matter of seconds!

And that's not all! The computing director makes instantaneous corrections for drift, air density, wind conditions, and gun muzzle velocity. In addition, it calculates the fuse setting on the shell—so that the burst will occur at the *calculated position* of the enemy plane.

Westinghouse is making hundreds of other weapons for victory such as: guns, shells, radio equipment, instruments, electric motors and generators, and propulsion equipment for our giant battleships and rapidly growing merchant marine. And delivering these war materials faster than ever!

We are proud of the way Westinghouse "know-how" is adding day-by-day to America's tremendous striking power—on land, at sea, and in the air!

Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.



Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

The inauguration of the Gulf fellowships is an attempt to repay to some degree a debt to science and at the same time to increase the number of trained and able men who may contribute to the industrial, social, and economic advancement of America.

Only One Request Made by Gulf

The only condition that in any way limits the schools in selecting a candidate is a provision that if one of the applicants for a fellowship is the child of a Gulf employee and his qualifications are equal to those of others competing, the son or daughter of our employee shall be given preference.

The Gulf Companies will make no attempt to direct or administer the fellowships. They are to be wholly under the jurisdiction of the various schools who are granted the utmost freedom in selecting the fellows and in directing their work. During the three-year term of each fellowship, the recipient is under absolutely no obligation to the Gulf Companies. Neither is he under any obligation to take employment with Gulf or to follow any specific line of endeavor following its completion.

Registered Engineers Directory to Be Ready in Summer

A "United States Directory of Registered Professional Engineers," verified and certified by the National Council of State Boards of Engineering Examiners, is now expected to be available early this summer.

•

Corrections to

A.S.M.E. Power Test Code for Steam Turbines

THE attention of the A.S.M.E. Committee on Power Test Codes has been called to a number of errors and ambiguities that require correction and clarification in the 1941 edition of the Test Code for Steam Turbines. Offset copies of these corrections have been prepared and may be obtained upon application to the A.S.M.E. Publication Sales Department, 29 West 39th Street, New York, N. Y.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after April 24, 1943, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

AIKINS, WM. R., Hamilton, Ont., Canada
ANDERSON, GUSTAVE W., Montgomery County, Pa.
BONDON, LEWIS A., Arlington, N. J.
BOWIE, HARRY J., Hatboro, Pa.
BREWER, NATHANIEL, Hatfield, Pa.
BULGER, WM. A., Stamford, Conn.
CAMPBELL, C. LANGDON, Charleston, W. Va.
CANGIALOSI, JOHN C., Hoboken, N. J. (Re)
DERBY, ROBT. E., Philadelphia, Pa. (Re)
DRAXLER, JOHN A., Cleveland, Ohio
DUNN, RAYMOND G., Portland, Oregon
ENDER, JOS. J., Grand Rapids, Mich.
GAICOMBE, ERNEST K., Ithaca, N. Y.
GIBBS, MAXWELL, Los Angeles, Calif.
GRIGOR, CHAS. S., Long Beach, Calif. (Rt)
GUTZWILLER, ERWIN C., JR., Toledo, Ohio (Re)
HAINES, CHAS. S., II, Tarrytown, N. Y.
HARDY, CARROLL F., Cincinnati, Ohio
HARRIS, CHAS. O., Chicago, Ill.
HAWKINS, WILFORD J., New Haven, Conn.
HOMAN, JACK L., Dayton, Ohio
HOWE, WM. W., San Rafael, Calif.
HUMBERT, W. F., Spray, N. C.
JOHNSON, JOHN A., Wauwatosa, Wis.
JOHNSTON, J. BRUCE, Coatesville, Pa.
JONES, JOHN L., Blacksburg, Va.
KEACHIE, E. C. (LIEUT.), San Francisco, Calif.
KELL, WALDO R., Kansas City, Kans. (Rt & T)
KELLER, HENRY C., Syracuse, N. Y.
KELLER, HENRY CHRISTIAN, Syracuse, N. Y.
KLIMENT, W. P., Cicero, Ill.
LAUER, WM. N., River Forest, Ill. (Rt)
LEET, LESLIE, Westfield, N. J. (Rt)
LEUTHESSER, F. W., JR., Chicago, Ill.
MARSLEK, EMIL J., Cicero, Ill.
METCALF, ROBT. F., JR. (CAPT.), Watertown, Mass. (Rt)
MCCORKLE, LEE R., Chicago, Ill.
MILLER, RICHARD O., Waterbury, Conn. (Rt)
MILLER, W. H., Columbia, Mo.
MONGELLO, THOMAS, Queens Village, N. Y.
MORGAN, GLEN W., Provo, Utah
NEIFERT, HARRY R., Canton, Ohio
ODELL, I. N., Rochester, N. Y.
OLDENKAMP, HENRY A., Cleveland, Ohio
RATHE, ALEX W., Jersey City, N. J.
REINHART, CHAUNCEY O., Roselle, N. J.
REPETTO, FELIX E., Belmont, Mass. (Rt & T)
RIPPEY, GEO. S., Boston, Mass.
ROOT, V. A., Rockford, Ill. (Rt & T)
SIMPSON, R. T. (COMDR.), Wynnewood, Pa.
SISSON, EDMOND F., Pensacola, Fla.
SMITH, GUY P., Latrobe, Pa.
STAVER, ROBT. B., Arlington, Va.
STOLL, KARL E., Pekin, Ill.
STRACHAN, A. D., Boston, Mass.
STRETT, JOHN W., Oakland, N. J.
SUPOVE, LAWRENCE, Portland, Oregon (Rt & T)
VALYI, E. I., New York, N. Y.
VOYCE, L. C., New York, N. Y.
WESTIN, LLOYD J., Philadelphia, Pa.
WIED, JULIUS, East Cleveland, Ohio
WRIGHTMAN, S. A., Denver, Colo.
WOOD, A. GORDON, Vallejo, Calif.
WOOD, R. LEE, Chicago, Ill.
ZEUS, WM., Kenilworth, N. J.

CHANGE OF GRADING

Transfer to Fellow

WITT, J. C., Chicago, Ill.

Transfers to Member

AUGHENBAUGH, ELMER E., York, Pa.
CAMMANN, OSWALD, Weston, Mass.
CARTER, LOUIS E., Baltimore, Md.
HANHART, ERNEST H., Baltimore, Md.
LEE, ROBERT J., Philadelphia, Pa.
MURPHY, ROBT. J., Jersey City, N. J.
SELIG, ERNEST T., JR., Pando, Colo.
SORENSEN, HARRY A., State College, Pa.
STEPHENSON, A. M., Cleveland, Ohio
THOMSON, R. R., Kansas City, Mo.

A.S.M.E. Transactions for March, 1943

THE March, 1943, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

Calculation of Load and Stroke in Oil-Well Pump Rods, by B. F. Langer and E. H. Lamberger

The Distribution of Strains in the Rolling Process, by C. W. MacGregor and L. F. Coffin, Jr.

The Relationship Between Reynolds Number and Velocity Distribution, by L. S. Rhodes

Oscillations of Suspension Bridges, by Hans Reissner

DESIGN DATA

Harmonic Coefficients of Engine Torque Curves, by F. P. Porter

DISCUSSION

On previously published papers by L. H. Donnell; E. S. Dennison

BOOK REVIEWS

Necrology

THE deaths of the following members have recently been reported to headquarters:

ASHLEY, FRANK M., October 5, 1942
BALTZELL, WILL H., September 2, 1942
BLUNT, JAMES G., February 15, 1943
BRISTOL, BENNET B., November 10, 1942
BROWN, ARTHUR G., January 14, 1943
DAGGETT, JOHN F., December 12, 1942
DINEEN, JOSEPH D., November 28, 1942
HEDRICK, EARLE R., February 3, 1943
KAHN, JULIUS, November 4, 1942
KIDDE, WALTER, February 9, 1943
NITZ, HARVEY I., December 8, 1942*
O'REILLY, ANDREW J., January 27, 1943
SANDERSON, EDWARD S., February 13, 1943
STEVENS, BURT D., February 4, 1943

* Died in line of duty.